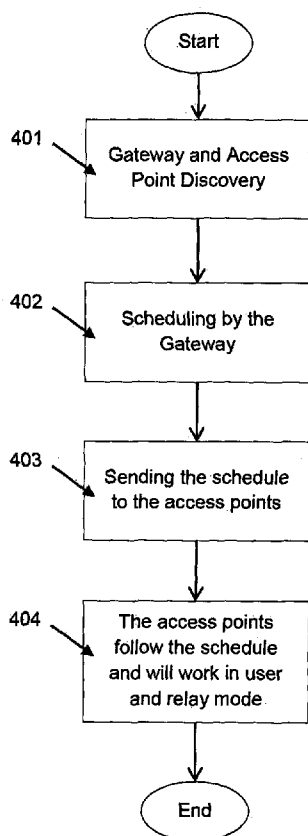




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(54) Title: A METHOD AND SYSTEM FOR TRANSMITTING AND RECEIVING DATA PACKETS IN A WIRELESS MULTI-HOP NETWORK



(57) Abstract: The present invention relates to method and system for transmitting and receiving data packets in a wireless multi-hop network. A gateway (100) in the network schedules each access point (200) to operate in user mode and relay mode, wherein at any period of time only the access points (200) in a specific hop operate in the user mode while the access points (200) in other hops operate in the relay mode. During the user mode, the access point (200) is able to communicate with its user devices (300) while only able to transmit to its neighbouring access points (200). During the relay mode, the access point (200) is able to communicate with its neighbouring access points (200) while only able to transmit to its user devices (300).



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**A METHOD AND SYSTEM FOR TRANSMITTING AND RECEIVING DATA
PACKETS IN A WIRELESS MULTI-HOP NETWORK**

FIELD OF INVENTION

5 The present invention generally relates to a wireless multi-hop network and in particular to a method and system for transmitting and receiving data packets in a wireless multi-hop network.

BACKGROUND OF THE INVENTION

10 In a wireless multi-hop network, a plurality of access points is interconnected to extend network coverage. Moreover, each access point is connected to multiple user devices and at least one of the access points is connected to a gateway for accessing the Internet or other network. Thus, each access point is able to send and receive data packets to/from user devices as well
15 as to relay data packets for its neighbouring access points.

 The transmission of data packets for an access point is affected by the network size, wherein as the network size increases, this reduces the transmission of data packets by the access point. This is due to the fact that as the network size
20 increases, the number of access points increases and thus, causing bottleneck at the access points directly connected to the gateway as the accumulated data relayed to it increases.

 Moreover, if a particular access point has high data traffic in relaying data
25 packets from its neighbouring access points, the user devices connected to that particular access point experience low data throughput. In fact, as the traffic on one access point increases, its relaying capability for the other access points is affected. In particular, the access points with higher number of hops to a gateway experiences low data throughput and also, the user devices connected to the
30 access points with higher number of hops experience slow data connection to access the Internet or other network. The reason being is that the data packets are queuing in an access point for longer time period before being relayed to the next hop and such queuing is repeated at each hop until it reaches the gateway.

FIG. 1 shows an example of a wireless multi-hop network, wherein the wireless multi-hop network comprises of a gateway (not shown), three access points (10) and three user devices (20). A first access point (10a) is wirelessly connected to a first user device (20a) and the gateway, a second access point (10b) is wirelessly connected to a second user device (20b) and the first access point (10a), and a third access point (10c) is wirelessly connected to a third user device (20c) and the second access point (10b). If either the first or the second access point (10a, 10b) has high data traffic for transmitting data packets, this causes the congestion in the network and thus, the third access point (10c) which is two hops away from the gateway experiences low data throughput and also, the third user device (20c) experiences a slow connection to access the Internet or other network via the gateway. This is due to the fact that the data packets from the third user device (20c) need to be in queue in the second access point (10b) before being relayed to the first access point (10a) and thereon, the data packets are being queued again in the first access point (10a) before being relayed to the gateway.

In regard to this, several efforts have been made to schedule the transmission of data packets in the wireless multi-hop network. In PCT Publication No. WO 2007/114857, systems and methods are described that facilitate controlling transmission/reception time slots in a wireless multi-hop ad hoc network. A node, such as an access terminal or an access point, may select an identifier that corresponds to specific time slots during which nodes with that particular identifier may transmit and/or receive. Nodes that are one hop away from each other may select different identifiers in order to ensure that neighbouring nodes do not transmit and/or receive during the same time slots. In this manner, interference caused and/or experienced by a given node may be reduced.

In US Patent Application No. 2007/0058604, there is provided a method and apparatus for scheduling the transmission of data packets over a multi-hop wireless backhaul network in which delay guarantees through the network may be advantageously ensured. Illustratively, a novel packet scheduling scheme is provided which is advantageously based on an existing scheduling policy for wireline networks and for which a delay guarantee (based on the delay characteristics of the existing scheduling policy) can be advantageously ensured.

In one embodiment, an even-odd link activation framework is defined for a given multi-hop wireless backhaul network, and an associated scheduling policy based on an arbitrary existing scheduling policy for wireline networks is derived and adopted. In such a case, the derived scheduling policy, when applied to the given multi-hop wireless backhaul network, advantageously ensures a worst-case delay guarantee of approximately twice that of the existing scheduling policy for wireline networks.

In PCT Publication No. WO 02/37752, there is provided the scheduling of data transfers in a multi-hop packet network. The nodes of the network are adapted to schedule their transmissions according to a common time sequence, recurring in time domain and comprising a control portion for transmission of at least one control packet and a data portion for transmission of data packets. In order to accomplish a simple and controlled way for minimizing delay and delay variation, the network is classified into several levels with respect to a certain node, each level comprising the nodes located at the same distance from said certain node, measured in number of hops along the shortest path in the network. The data portion is further divided into successive reservation periods, each being allocated to transmissions of delay sensitive traffic through the hops between two predetermined neighbouring levels so that a data packet can be transferred across the network within a single time sequence.

Therefore, there is a need to provide a method and system for scheduling the transmission and reception of data packets in a wireless multi-hop network that addresses the aforementioned drawbacks.

SUMMARY OF INVENTION

In one aspect of the present invention, a method for transmitting and receiving data packets in a wireless multi-hop network is provided. The method is characterised by the steps of determining quantity of access points (200) in the network and distance in number of hops of each access points (200) from a gateway (100); scheduling each access point (200) to operate in user mode and relay mode, wherein each access point operating in the user mode is able to transmit data packets to at least one neighbouring access point (200) and at least one user device (300), and able to receive data packets from the at least one user device (300) while

queuing the data packets received from the at least one neighbouring access point (200), and wherein each access point operating in the relay mode is able to transmit data packets to at least one neighbouring access point (200) and at least one user device (300), and able to receive data packets from the at least one neighbouring access point (200) while queuing the data packets received from the at least one user device (300); transmitting the schedule to each access point (200); synchronizing the clock between the gateway (100) and the access points (200); and operating each access point (200) in either the user mode or relay mode based on current time and the schedule provided by the access point (200).

Preferably, the step of scheduling each access point further includes the steps of selecting a time window (T) by the gateway (100); dividing the time window (T) with the maximum number of hops in the network (K) by the gateway (100); and assigning each time period to the access points (200) in each hop to operate in user mode.

Preferably, the step of transmitting the schedule to each access point (200) further includes synchronizing the clock between the gateway (100) and the access points (200).

Preferably, the step of operating each access point (200) in the user mode further includes the steps of transmitting data packets to at least one neighbouring access point (200); transmitting and receiving data packets to/from at least one user device (300); and queuing data packets received from the at least one neighbouring access point (200).

Preferably, the step of operating each access point (200) in the relay mode further includes the steps of transmitting and receiving data packets to/from at least one neighbouring access point (200); transmitting data packets to at least one user device (300); and queuing data packets received from the at least one user device (300).

In another aspect of the present invention, a system for transmitting and receiving data packets in a wireless multi-hop network is provided. The system comprises of a gateway (100), a plurality of access points (200), and a plurality of

user devices (300). The gateway (100) is configured to determine the quantity of access points in the network and the distance of each access point (200) in number of hops from the gateway (100), and to develop a data transmission schedule, wherein the data transmission schedule schedules each access point (200) to
5 operate in relay mode and user mode. Each access point (200) is configured to operate in either user mode or relay mode at any period of time based on the data transmission schedule, wherein the access point (200) is able to transmit and receive data packets to/from the user devices (300) and able to transmit data packets to its neighbouring access points (200) during the user mode, and wherein the access
10 point (200) is able to transmit and receive data packets to/from its neighbouring access points (200) and able to transmit data packets to the user devices (300) during the relay mode.

Preferably, each access point (200) includes at least three antennas (210),
15 wherein each antenna (210) is assigned to connect to either gateway (100), neighbouring access points (200) or the user devices (300); at least three interface components (240), wherein one interface component (240) is connected to each antenna (210); at least three buffer components (250), wherein the at least three buffer components (250) are used to queue and temporarily store the data packets
20 based on the data transmission schedule, and wherein one buffer component (250) is connected to each interface component (240); a processor (230), wherein the processor (230) includes a schedule monitoring module (231) and an interface management module (232), and wherein the schedule monitoring module (231) is used to execute the data transmission schedule, and wherein the interface
25 management module (232) is used to manage the interface and buffer components (240, 250) for transmission and reception of data packets to/from the user devices (300) and neighbouring access points (200) based on the data transmission schedule; and a memory (220), wherein the memory (220) is coupled to the processor (230).

30

Advantageously, the present invention balances traffic load of the access points in a wireless multi-hop network.

35

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 an example of an existing wireless multi-hop network.

FIGS. 2(a-b) show examples of a wireless multi-hop network.

10 **FIG. 3** shows a block diagram of an access point (200) according to an embodiment of the present invention.

FIGS. 4(a-d) show flowchart diagrams of a method for transmitting and receiving data packets in a wireless multi-hop network according to an embodiment of the
15 present invention.

FIG. 5 shows a flow diagram of gateway advertisement message and gateway discovery message flow in the wireless multi-hop network of **FIG. 2a**.

20 **FIG. 6(a-c)** show timing diagrams of scheduled data transmission for each access point (200) in a wireless multi-hop network according to an embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

25 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.

30 **FIGS. 2(a-b)** show examples of a wireless multi-hop network, wherein the network generally comprises of a gateway (100), a plurality of access points (200), and a plurality of user devices (300).

The gateway (100) is used for accessing to the Internet, an Ethernet, local
35 area network (LAN), wide area network (WAN) or any other appropriate network. In

addition to that, the gateway (100) is used to determine the quantity of access points in the network and the distance of each access point (200) from the gateway (100). The distance from the gateway (100) to an access point (200) is measured as the number of hops required to reach the access point (200) from the gateway (100).

5 Based on the information of the quantity and maximum distance of the access points (200) in the network, the gateway (100) develops a data transmission schedule which schedules each access point (200) to operate in relay mode and user mode. The data transmission schedule is then transmitted to the access points (200). The gateway (100) is connected to one of the access points (200). In FIG 2a, the gateway
10 (100) is connected to a first access point (200a). Although the network is shown as having only one gateway (100) connected to an access point (200a), it is appreciated that the network may include any suitable number of gateway (100) connected to any suitable number of access points (200).

15 The access points (200) are interconnected via a wireless communication technology such as but not limited to WiFi, WiMax, IEEE 802.11 based communications and etc. In FIG. 2a, the first access point (200a) is connected to a second access point (200b), the second access point (200b) is connected to the first access point (200a) and a third access point (200c). Each access point (200) is able
20 to relay data packets to/from its neighbouring access points. Moreover, each access point (200) communicates with at least one user device (300) such as but not limited to laptop, mobile phone, personal computer, handheld communication device, handheld computing device, wireless modem card or any other device suitable for communicating wirelessly within the wireless multi-hop network. As shown in FIG. 2a,
25 the first access point (200a) is connected to a first user device (300a), the second access point (200b) is connected to a second user device (300b), and the third access point (200c) is connected to a third user device (300c). Although the network is shown as having only one user device (300) connected to each access point (200), it is appreciated that the network may include more than one user device (300)
30 connected to each access point (200). The access points (200) operate in either user mode or relay mode at a period of time as scheduled by the gateway (100).

Referring now to FIG. 3, there is shown a block diagram of the access point (200) used in the wireless multi-hop network. The access point (200) includes at least
35 three antennas (210), a memory (220), a processor (230), at least three interface

components (240), and at least three buffer components (250). Moreover, the access point (200) may further includes a plurality of components associated with signal transmission and reception such as but not limited to modulators, multiplexers, de-modulators, de-multiplexers and etc. as will be appreciated by one skilled in the art.

5

Each antenna (210) is assigned to connect to either gateway (100), neighbouring access points (200) or the user device (300); wherein a first antenna (210a) is used for communicating with the gateway (100) or any neighbouring access point (200) which is nearer in number of hops to the gateway (100), a second antenna (210b) is used for communicating with the user device (300), and a third antenna (210c) is used for communicating with any neighbouring access point (200) which is further in number of hops from the gateway (100). As an example, the first access point (200a) of FIG. 2a has the first antenna (210a) assigned for communicating with the gateway (100), the second antenna (210b) assigned for communicating with the first user device (300a), and the third antenna (210c) assigned for communicating with the second access point (200b); the second access point (200b) of FIG. 2a has the first antenna (210a) assigned for communicating with the first access point (200a), the second antenna (210b) assigned for communicating with the second user device (300b), and the third antenna (210c) assigned for communicating with the third access point (200c); and the third access point (200c) of FIG. 2a has the first antenna (210a) assigned for communicating with the second access point (200b), and the second antenna (210b) assigned for communicating with the third user device (300c).

25 The memory (220) is used to store data and information which includes address or identification of neighbouring access points, and data transmission schedule. The memory (220) can be either volatile memory, non-volatile memory or any other suitable types of memory. The memory (220) is coupled to the processor (230).

30

The processor (230) includes a schedule monitoring module (231) and an interface management module (232). The schedule monitoring module (231) is used to execute the data transmission schedule sent by the gateway (100) and thus, directing the access point (200) to operate in either the user mode or relay mode at a period of time as defined by the data transmission schedule. The interface

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management module (232) is used to manage the interface and buffer components (240, 250) for transmission and reception of data packets to/from the user device (300) and neighbouring access points (200) based on the data transmission schedule.

5

The interface components (240) are used to enable wireless communication. One interface component (240) is connected to each antenna (210), wherein a first interface component (240a) is connected to the first antenna (210a), a second interface component (240b) is connected to the second antenna (210b), and a third interface component (240c) is connected to the third antenna (210c).

10

The buffer components (250) are used to queue and temporarily store the data packets. One buffer component (250) is allocated and connected to each interface component (240). A first buffer component (250a) is connected to the first antenna (210a) through the first interface component (240a), a second buffer component (250b) is connected to the second antenna (210b) through the second interface component (240b) and a third buffer component (250c) is connected to the third antenna (210c) through the third interface component (240c). During the user mode, data packets received by the first and third antenna (210a, 210c) are queued and temporarily stored in the first and third buffer components (250a, 250c) respectively. During the relay mode, data packets received by the second antenna (210b) are queued and temporarily stored in the second buffer component (250b).

15

20

Referring to FIG. 4a, there is shown a general flowchart of a method for transmitting and receiving data packets in a wireless multi-hop network according to an embodiment of the present invention.

25

Initially, as in step 401, the gateway (100) determines the quantity of access points (200) in the network and the distance in number of hops of the access points (200) from the gateway (100). This is done by broadcasting a gateway advertisement message which is relayed by each access points (200) and thereon, the gateway advertisement message is replied with a gateway discovery message by the access points (200) in the network.

30

Thereon, in step 402, the gateway (100) develops the data transmission schedule for scheduling each access point (200) to operate in user mode and relay mode. The data transmission schedule comprises of user mode and relay mode. The user mode refers to a timeslot wherein an access point is able to transmit and receive data packets to and from the user devices (300) and also, the access point (200) is able to only transmit data packets to its neighbouring access points (200). Moreover, the data packets from its neighbouring access points (200) are queued in its buffer components (250). On the other hand, the relay mode refers to a timeslot wherein an access point (200) is able to transmit and receive data packets to/from its neighbouring access points (200) and also, the access point (200) is able to only transmit data packets to the user devices (300) connected to it. Moreover, the data packets from the user devices (300) which are connected to it are queued in one of its buffer components (250). In transitioning between the user mode and relay mode, there is a delay time to prevent collision between the traffic in user mode and the traffic in relay mode.

The data transmission schedule is then transmitted to each access point (200) as in step 403. In particular, the gateway (100) sends the schedule to the access points (200) connected to it, and the access points (200) relay the schedule to its neighbouring access points (200). This step includes sending time synchronization message to all access points (200) by the gateway (100). The time synchronization message functions to synchronize the clock between the gateway (100) and the access points (200).

In step 404, each access point (200) operates in either the user mode or relay mode based on the schedule provided by the gateway (100).

Referring now to FIG. 4b, there is shown a flowchart of a method for determining the quantity of access points (200) in the network and the distance in number of hops of the access points (200) from the gateway (100) as in step 401 of FIG. 4a. In step 501 and 502, the gateway (100) is initiated and a gateway advertisement message is broadcasted by the gateway (100) to all access points (200) connected to it. Thereon, if the access points (200) receive the gateway advertisement message, the access points (200) broadcast the gateway advertisement message to its neighbouring access points (200) and the access

points (200) reply to the gateway advertisement message with a gateway discovery message (decision 503, step 505 and 506). Otherwise, the access points (200) wait to receive the gateway advertisement message as in decision 503 and step 504. Thus, the access points (200) which did not receive or reply the gateway advertisement message are not considered as part of the network.

Thereon, if the access points (200) which are connected to the gateway (100) receive the gateway discovery message from its neighbouring access points (200), the gateway discovery message is relayed to the gateway (100) and the gateway (100) determines the number of access points (200) in the network and the maximum number of hops of the access points (200) from the gateway (200) (decision 507, step 508 and 509). FIG. 5 shows a flow diagram of the gateway advertisement message flow and the gateway discovery message flow in the wireless multi-hop network of FIG. 2a.

15

However, if there is no reply from neighbouring access points (200) for a predetermined period of time, the gateway (100) proceed to determine the number of access points (200) in the network and the maximum number of hops of the access points (200) from the gateway (100) (decision 507, and step 509).

20

Referring now to FIG. 4c, there is shown a method for developing the data transmission schedule for scheduling each access point (200) to operate in user mode and relay mode as in step 402 of FIG. 4a.

25

Initially, as in step 601, the gateway (100) selects a time window (T). FIG. 6a shows a timing diagram of a time window selected by the gateway (100).

Thereon, as in step 602, the gateway (100) divides the time window (T) with the maximum number of hops in the network (K). As a result, the time window is divided into K number of time periods. FIG. 6b shows a timing diagram of a time window having K number of time periods.

Thereon, as in step 603, each time period is assigned for the access points (200) in each hop to operate in user mode. The gateway (100) assigns the time period for the access points (200) in each hop in a sequential manner. In particular,

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the gateway (100) assigns a first time period as the user mode for the access points (200) in the first hop, whereas the access points (200) in the other hops are assigned to operate in relay mode; a second time period is assigned as the user mode for the access points (200) in the second hop, whereas the access points (200) in the other hops are assigned to operate in relay mode; a third time period is assigned as the user mode for the access points (200) in the third hop, whereas the access points (200) in the other hops are assigned to operate in relay mode; and the following periods are assigned with the next hop until it reaches the maximum number of hop. Preferably, the gateway (100) assigns a delay time in each transition from the relay mode to the user mode. The scheduling is done in a way that assures at any period of time only the access points (200) in a specific hop operate in user mode while the access points (200) in the other hops operate in relay mode. FIG. 6c shows the timing diagram for the access point (200) in each hop scheduled to operate in user mode and relay mode.

An example of developing the data transmission schedule for the wireless multi-hop network of FIG. 2a is provided herein below. Initially, the gateway (100) determines that the quantity of access points (200) in the network is three access points (200) and the maximum number of hops in the network (K) is three hops. Thereon, the gateway (100) selects a value for T as 300ms and divides the time window (T) with the value of K which is three. Thus, a value of 100ms is obtained and the time window is divided into three time periods of 100ms. Thereon, the gateway (100) assigns a first time period as the user mode for the first access point (200a), whereas the access points (200b, 200c) in the other hops are assigned to operate in relay mode. A second time period is assigned as the user mode for the second access point (200b), whereas the access points (200a, 200c) in the other hops are assigned to operate in relay mode. A third time period is assigned as the user mode for the third access point (200c), whereas the access points (200a, 200b) in the other hops are assigned to operate in relay mode.

Referring now to FIG. 4d, there is shown a method for operating an access point (200) in user mode and relay mode as depicted by step 404 of FIG. 4a. Once the access point (200) has received the data transmission schedule, the access point (200) starts operating and monitoring to transmit and receive data packets based on the schedule provided (step 701 and 702). More particularly, the access point (200)

determines whether to operate in either user mode or relay mode based on current time and the schedule provided.

If the access point (200) is required to operate in relay mode, the processor (230) allows the first interface component (240a) for connecting to the gateway (100) or to its neighbouring access point (200) which is nearer in number of hops to the gateway (100) to receive and send data packets (decision 703 and step 704). Thereon, in step 705, the second interface component (240b) for connecting to the user devices (300) queues the data packets received from the user devices (300) in the second buffer component (250b). However, the second interface component (240b) is able to transmit data packets to the user devices (300). In step 706, the processor (230) allows the third interface component (240c) for connecting to its neighbouring access point (200) which is further in number of hops from the gateway (100) to receive and send data packets. As an example, the second access point (200b) of FIG. 2a operating in relay mode is able receive and send data packets to the first and third access point (200a, 200c) while only able to transmit data packets to the second user device (300b). Moreover, the data packets received from the second user device (300b) are queued in its second buffer component (250b).

However, if the access point (200) is required to operate in user mode, the access point (200) waits for a period of the delay time and thereon, the processor (230) of the access point (200) allows the first interface component (240a) for connecting to the gateway (100) or to its neighbouring access point (200) which is nearer in number of hops to the gateway (100) to send data packets (decision 703; steps 707 and 708). The data packets received from the gateway (100) or the neighbouring access point (200) which is nearer to the gateway (100) are queued in the first buffer component (250a). Thereon, the processor (230) allows the second interface component (240b) for connecting to the user devices (300) to send and receive data packets (step 709). In step 710, the processor (230) allows the third interface component (240c) for connecting to a neighbouring access point (200) which is further in number of hops from the gateway (100) to send data packets. The data packets received from the neighbouring access point (200) are queued in the third buffer component (250c). As an example, the second access point (200b) of FIG. 2a operating in user mode is able receive and send data packets to the second user device (300b) while able to only transmit data packets to the first and third

access points (200a, 200c). Moreover, the data packets received from the first and third access points (200a, 200c) are queued in its first and third buffer components (250a, 250c) respectively.

5 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 method for transmitting and receiving data packets in a wireless multi-hop network is characterised by the steps of:

a) determining quantity of access points (200) in the network and distance in number of hops of each access points (200) from a gateway (100);

b) scheduling each access point (200) to operate in user mode and relay mode, wherein each access point operating in the user mode is able to transmit data packets to at least one neighbouring access point (200) and at least one user device (300), and able to receive data packets from the at least one user device (300) while queuing the data packets received from the at least one neighbouring access point (200), and wherein each access point operating in the relay mode is able to transmit data packets to at least one neighbouring access point (200) and at least one user device (300), and able to receive data packets from the at least one neighbouring access point (200) while queuing the data packets received from the at least one user device (300);

c) transmitting the schedule to each access point (200);

d) synchronizing the clock between the gateway (100) and the access points (200); and

e) operating each access point (200) in either the user mode or relay mode based on current time and the schedule provided by the access point (200).

2. The method as claimed in claim 1, wherein scheduling each access point includes the steps of:

a) selecting a time window (T) by the gateway (100);

b) dividing the time window (T) with the maximum number of hops in the network (K) by the gateway (100); and

- c) assigning each time period to the access points (200) in each hop to operate in user mode.

5 3. The method as claimed in claim 1, wherein transmitting the schedule to each access point (200) further includes synchronizing the clock between the gateway (100) and the access points (200).

10 4. The method as claimed in claim 1, wherein operating the access point (200) in the user mode includes the steps of:

- a) transmitting data packets to at least one neighbouring access point (200);
- b) transmitting and receiving data packets to/from at least one user device (300); and

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- c) queuing data packets received from the at least one neighbouring access point (200).

20 5. The method as claimed in claim 1, wherein operating the access point (200) in the relay mode includes the steps of:

- a) transmitting and receiving data packets to/from at least one neighbouring access point (200);

- b) transmitting data packets to at least one user device (300); and

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- c) queuing data packets received from the at least one user device (300).

30 6. A system for transmitting and receiving data packets in a wireless multi-hop network comprising:

- a) a gateway (100),

- b) a plurality of access points (200), and

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- c) a plurality of user devices (300);

wherein the system is characterised in that:

the gateway (100) is configured to:

determine the quantity of access points in the network and the
5 distance of each access point (200) in number of hops from the
gateway (100), and

develop a data transmission schedule, wherein the data
transmission schedule schedules each access point (200) to operate
10 in relay mode and user mode; and

each access point (200) is configured to operate in either user mode
or relay mode at any period of time based on the data transmission schedule,
wherein the access point (200) is able to transmit and receive data packets
15 to/from the user devices (300) and able to transmit data packets to its
neighbouring access points (200) during the user mode, and wherein the
access point (200) is able to transmit and receive data packets to/from its
neighbouring access points (200) and able to transmit data packets to the
user devices (300) during the relay mode.

7. The system as claimed in claim 6, wherein each access point (200) includes:

at least three antennas (210), wherein each antenna (210) is assigned
to connect to either gateway (100), neighbouring access points (200) or the
user devices (300);

at least three interface components (240), wherein one interface
component (240) is connected to each antenna (210);

at least three buffer components (250), wherein the at least three
30 buffer components (250) are used to queue and temporarily store the data
packets based on the data transmission schedule, and wherein one buffer
component (250) is connected to each interface component (240);

a processor (230), wherein the processor (230) includes a schedule
35 monitoring module (231) and an interface management module (232), and

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wherein the schedule monitoring module (231) is used to execute the data transmission schedule, and wherein the interface management module (232) is used to manage the interface and buffer components (240, 250) for transmission and reception of data packets to/from the user devices (300) and neighbouring access points (200) based on the data transmission schedule; and

a memory (220), wherein the memory (220) is coupled to the processor (230).

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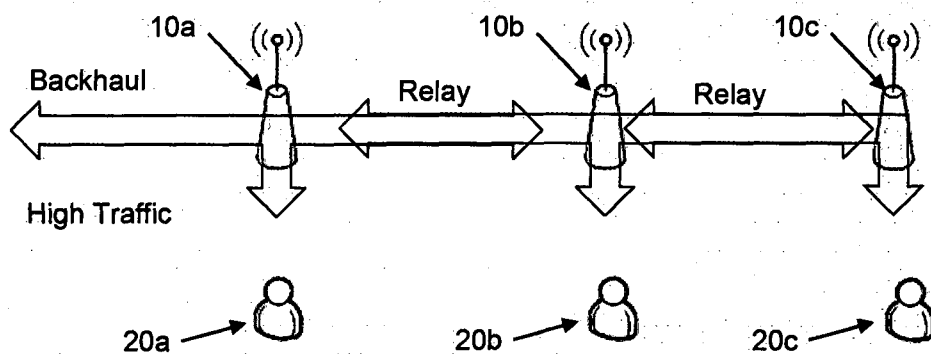


FIG. 1

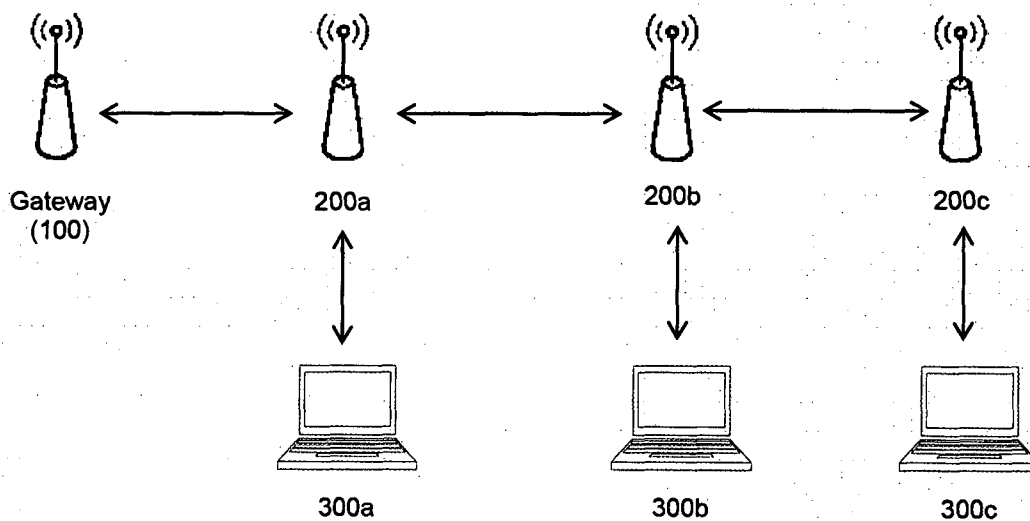


FIG. 2a

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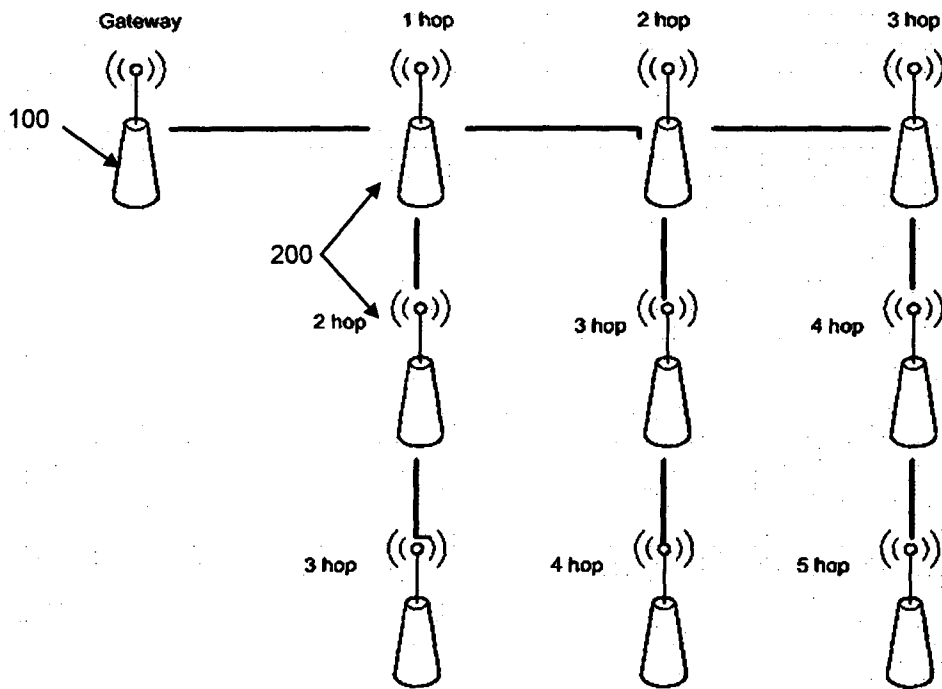


FIG. 2b

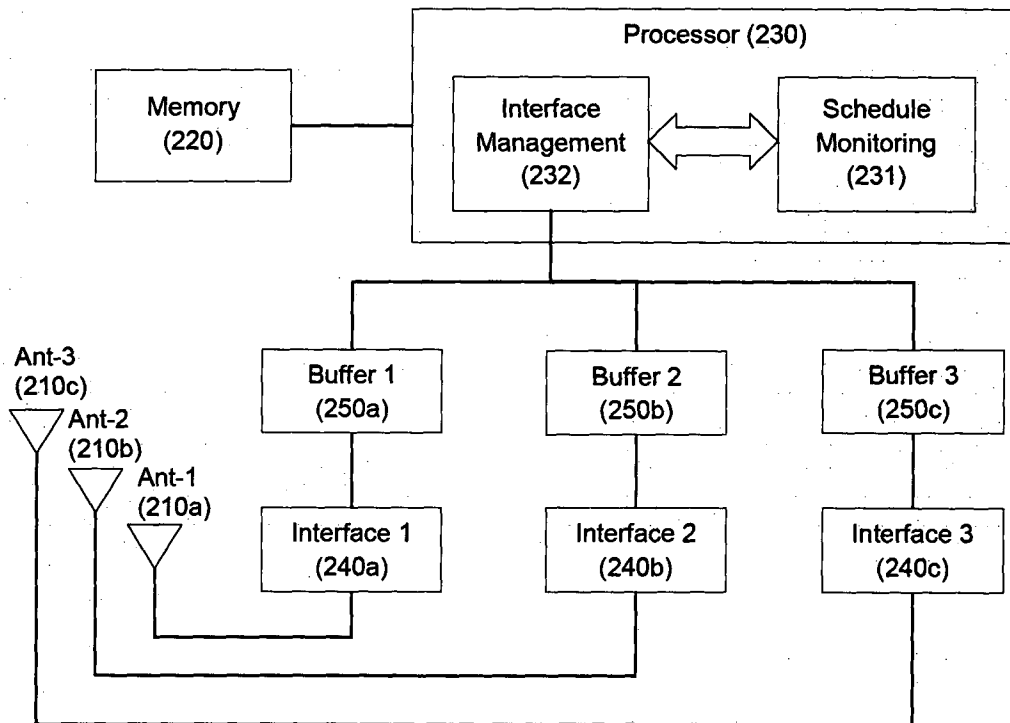


FIG. 3

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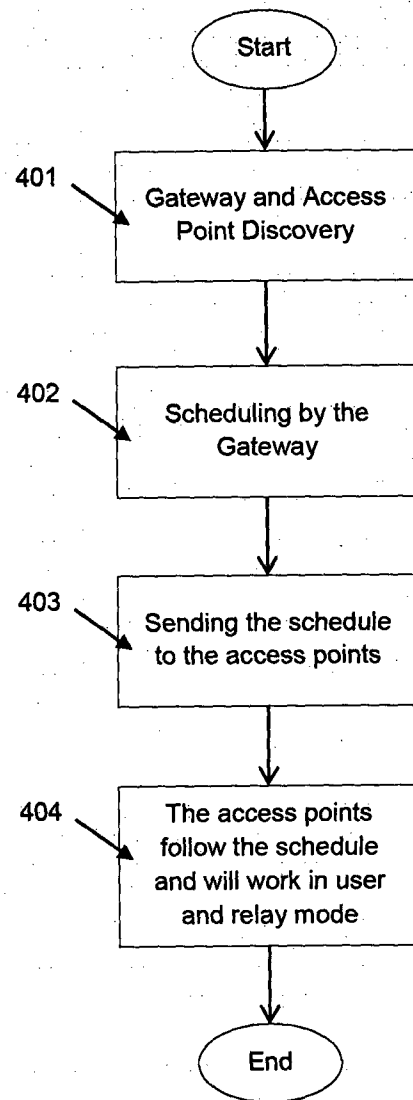


FIG. 4a

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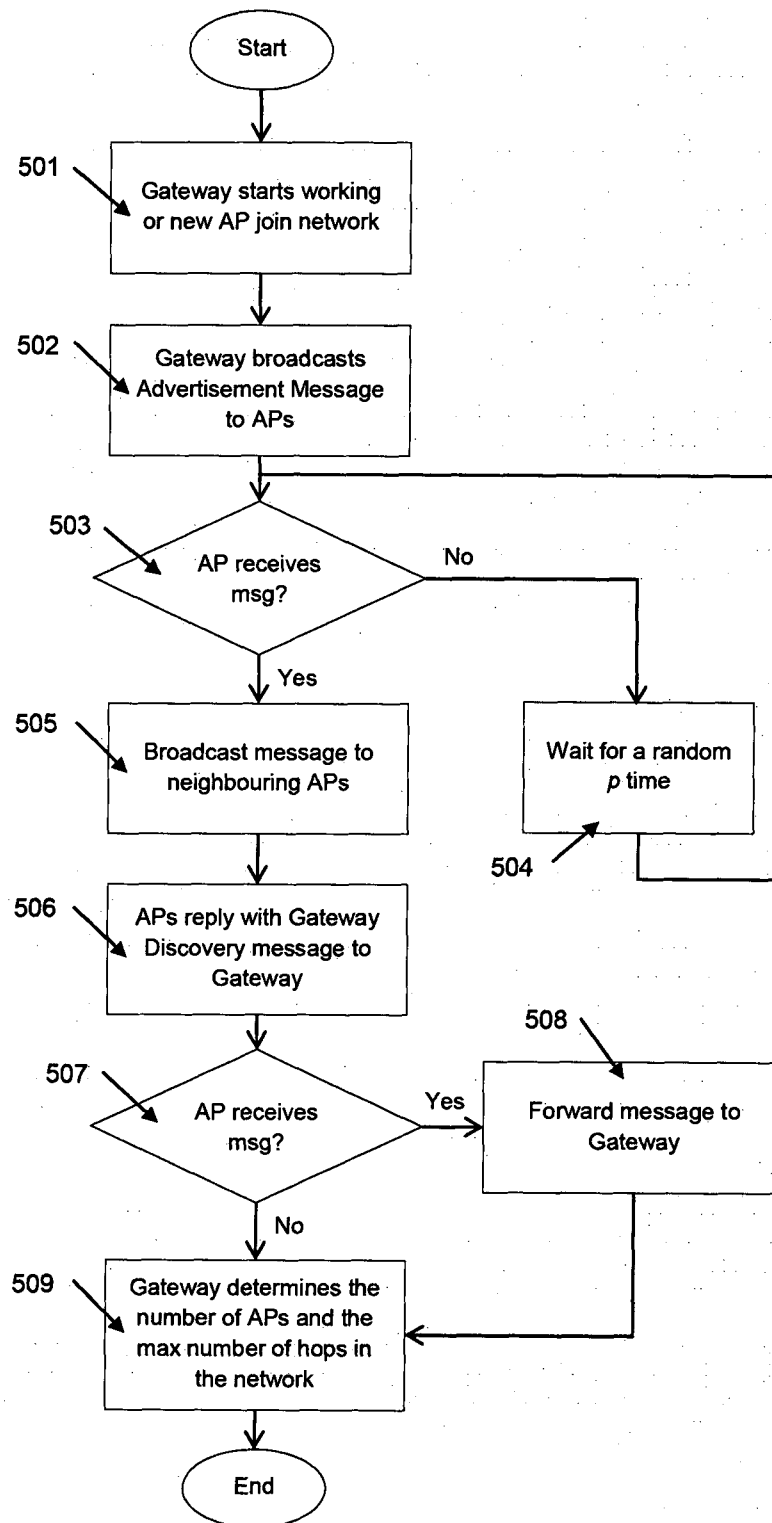


FIG. 4b

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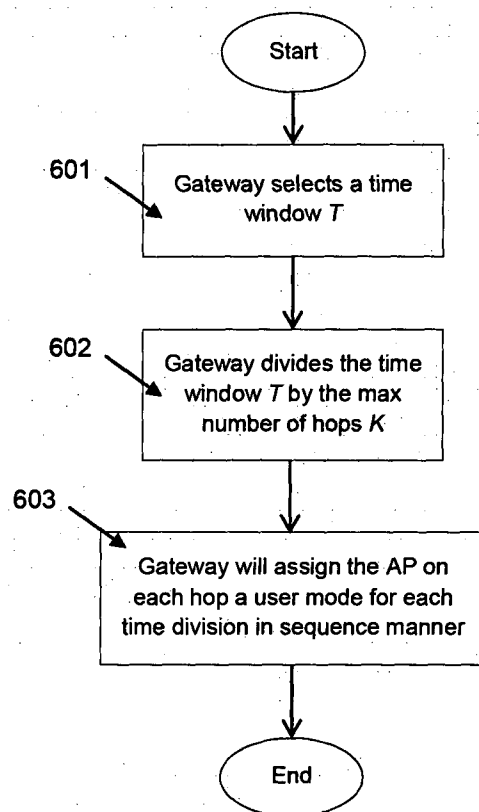


FIG. 4c

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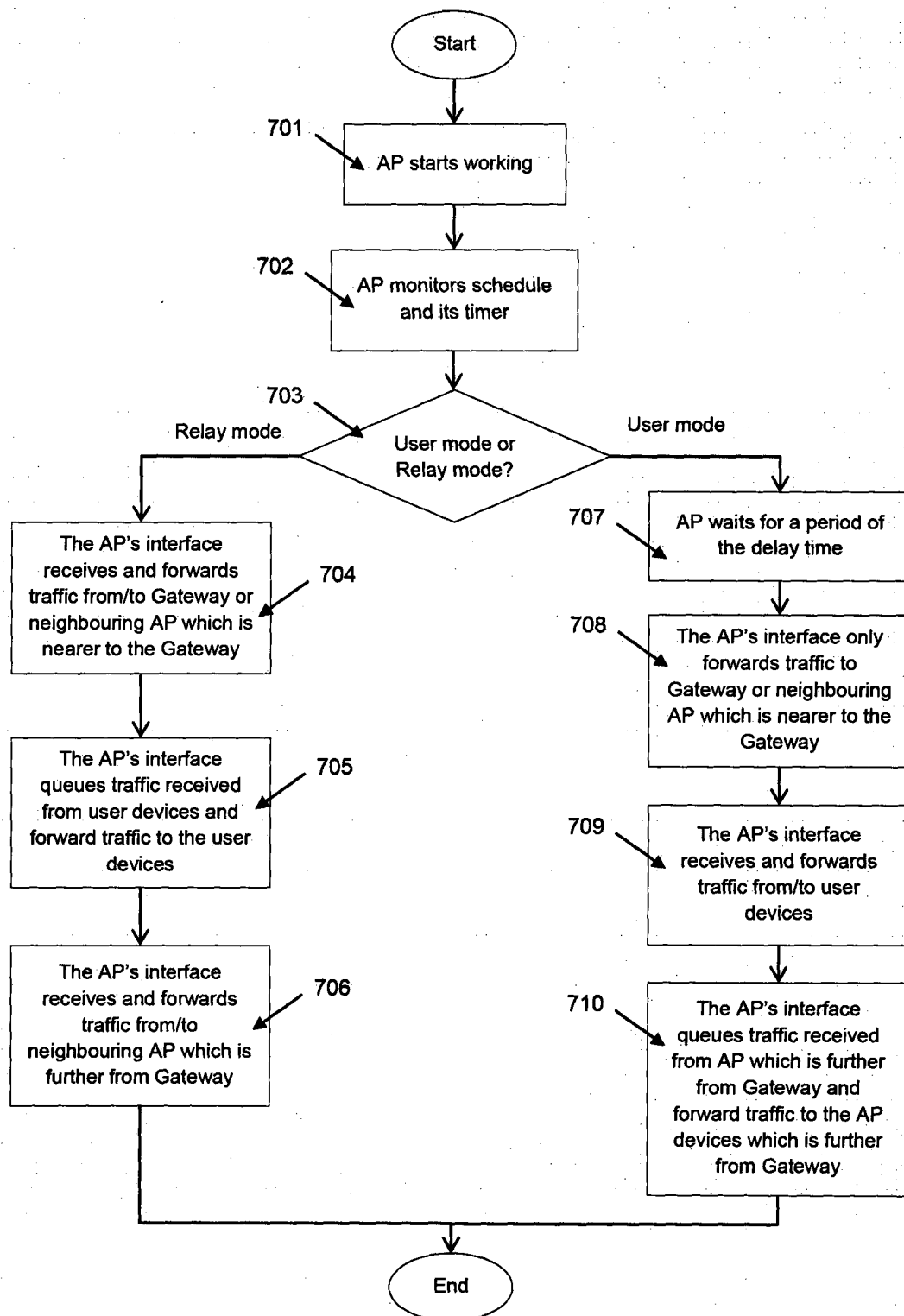


FIG. 4d

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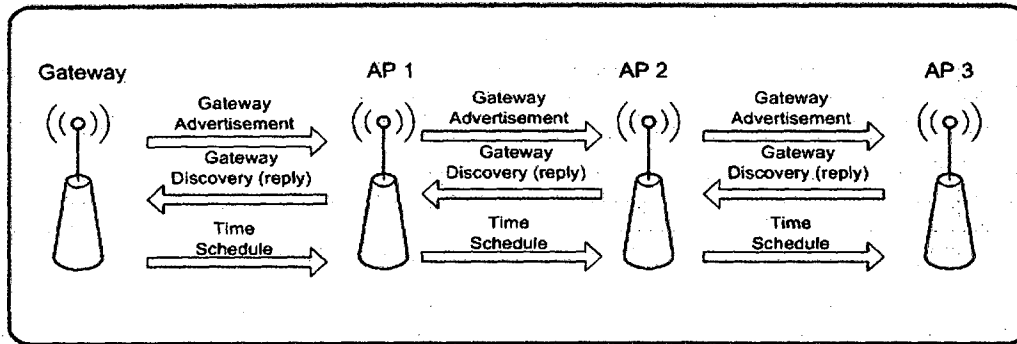


FIG. 5

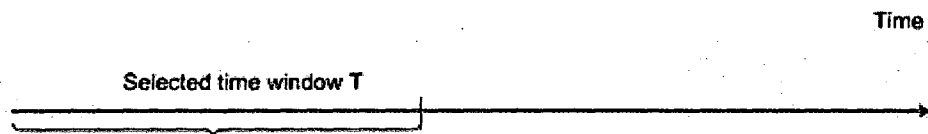


FIG. 6a

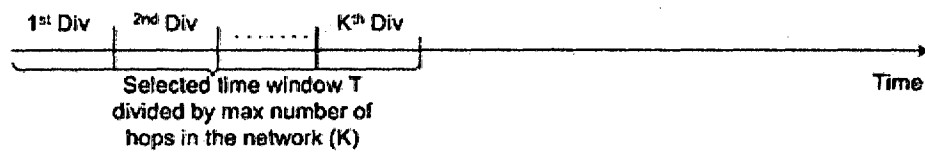


FIG. 6b

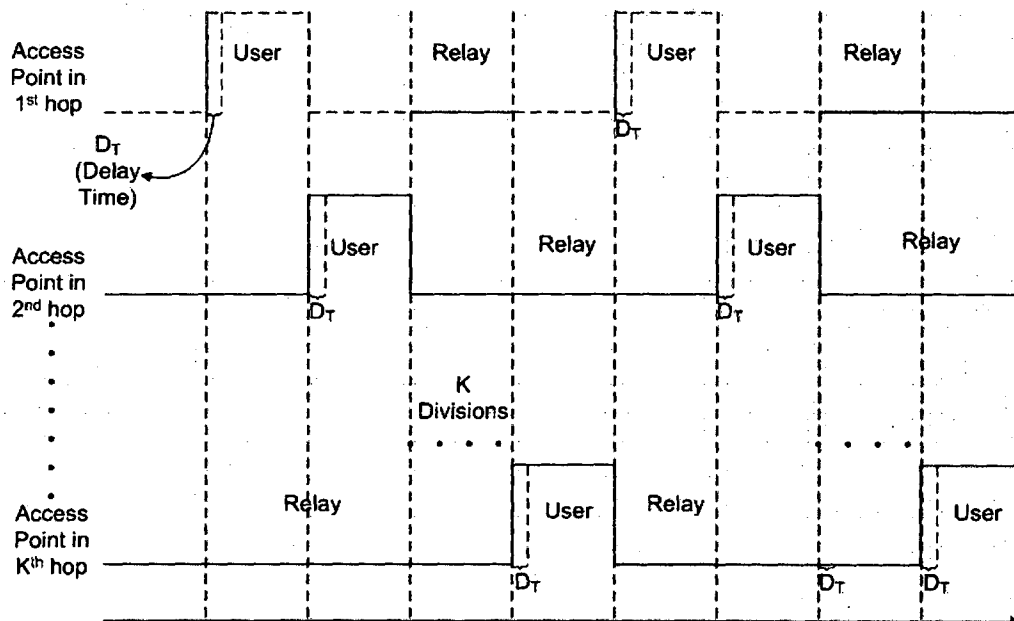


FIG. 6c