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(71) Applicant: **TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)** [SE/SE]; SE-164 83 Stockholm (SE).

(72) Inventors: **MAKKI, Behrooz**; Doktor Forselius gata 36, Lgh 1501, 413 26 Göteborg (SE). **COLDREY, Mikael**; Högvallagatan 9, 504 58 Borås (SE).

(74) Agent: **ERICSSON AB**; Patent Development, Torshamnsgatan 21-23, 164 80 Stockholm (SE).

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(54) **Title:** IMPROVED HANDLING OF RE-TRANSMISSIONS IN A WIRELESS COMMUNICATION NETWORK

(57) **Abstract:** The present disclosure relates to a node (AP2, U11) in a wireless communication system (1), wherethe node (AP2, U11) is adapted to communicate with at least two other nodes (AP1, AP0) in the wireless communication system (1), and where the other nodes (AP1, AP0) are first type nodes (AP1, AP0) which are adapted to communicate with each other by means of backhaul communication. The node (AP2, U11) is adapted to receive a signal (xA) transmitted from an adjacent first type node (AP1), where the signal (xA) has been forwarded from at least one farther first type node (AP0). In case of unsuccessful decoding of the signal (xA), the node (AP2, U11) is adapted to request re-transmission (NACK) of the signal (xA), and to receive a re-transmission of the signal (xA) directly from a farther first type node (AP0).(Fig. 3)

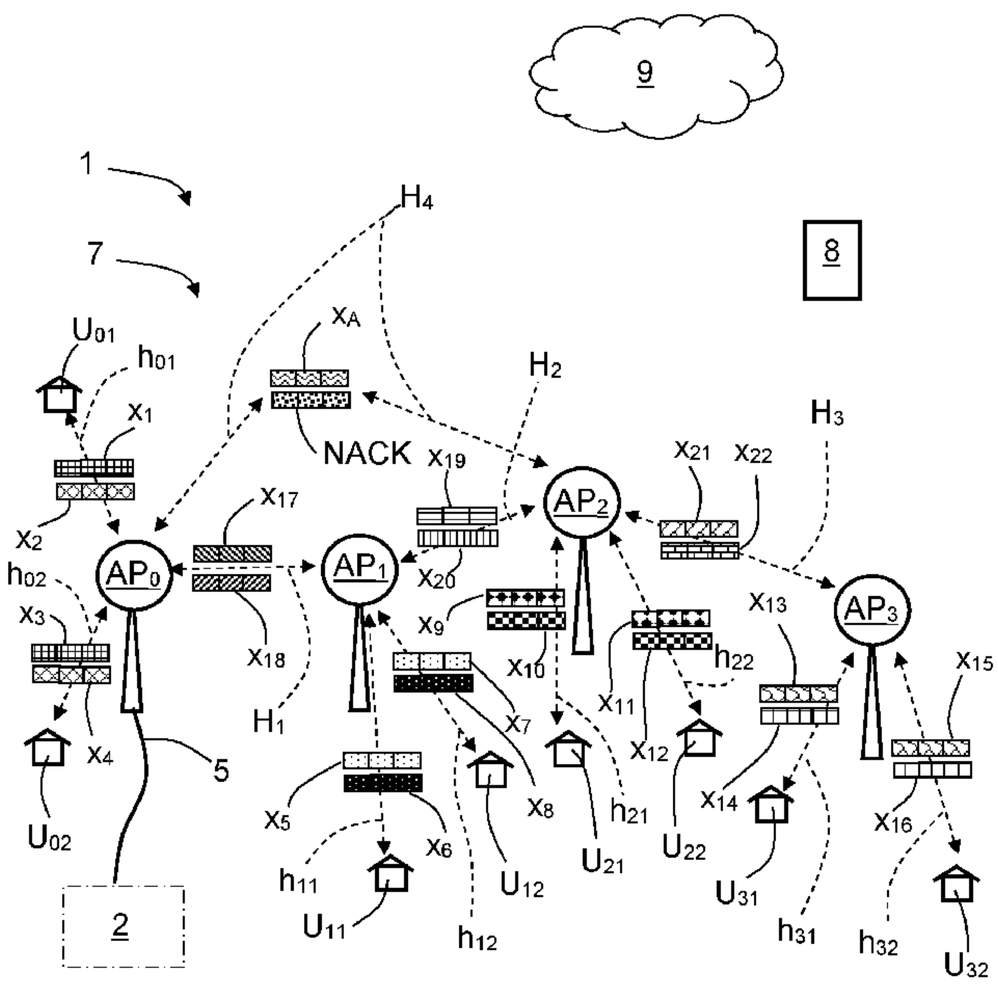


FIG. 3

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TITLE

Improved handling of re-transmissions in a wireless communication network

TECHNICAL FIELD

The present disclosure relates to relaying in wireless communication networks, in particular in integrated access and backhaul (IAB) networks.

BACKGROUND

The fifth generation of wireless networks (5G) must provide high-rate data streams for everyone everywhere at any time. To meet such demands, it is required to use large bandwidths. Here, it is mainly concentrated on millimeter wave-based, potentially, massive multiple-input and multiple-output (MMIMO), links as a key enabler to obtain sufficiently large bandwidths/data rates. Importantly, the presence of very wide bandwidths makes it possible to include the wireless backhaul transport in the same spectrum as the wireless access. In such a setup, there is thus a sharing of radio resources between access and backhaul links which implies that access and backhaul links compete over the same radio resources pool.

For this reason, 3GPP has considered such integrated access and backhaul (IAB) network configurations where an access point (AP), that for example can be fiber-connected, provides other APs as well as the customer-premises equipments (CPE:s) inside its cell area with wireless backhaul and access connections, respectively. The access-integrated backhaul link can either be a single-hop or multi-hop link in an IAB network. In a multi-hop deployment, the IAB network from one AP is relayed along a certain route from AP to AP until it reaches its destination. IAB networks can thus have either star-like configuration with multiple APs wirelessly backhauled through direct single-hop connections to the fiber-connected AP, or a cascade configuration with APs wirelessly connected to the fiber-connected AP in a multi-hop fashion.

It is desired to densify the network with a large number of access points (AP:s), each one serving a number of CPE:s inside its corresponding relatively small cell area. Compared to the cases with few macro base stations covering a wide area, less path loss/shadowing, and higher Line Of Sight (LOS) connection probability are expected in dense small-cell networks. As a result, better channel quality is experienced in these short-range links, compared to the cases with few macro base stations.

Among the advantageous of IAB networks are the followings:

Cost reduction:

A fiber optic link is relatively expensive in metropolitan areas, with a majority of the total figure tied to trenching and installation. For this reason, as well as the traffic jams and infrastructure displacements, some cities have considered a moratorium on fiber trenching specially in historical areas. In such scenarios, millimeter wave-based wireless backhaul is the best alternative providing almost the same rate as fiber optic with significantly less price and no digging.

Link quality enhancement:
Compared to the direct macro base station (BS)-CPE link, less path loss/shadowing, and higher line-of-sight (LOS) connection probability are expected for the wirelessly backhauled AP-CPE connections within small cells. As a result, better channel quality is experienced in such small cells, compared to the cases with direct macro BS-CPE connection.

Long-term network planning:
IAB systems are of most interest in small cell backhaul and fixed wireless access (FWA) networks with stationary APs/CPEs. This makes it possible to predict the channel quality and perform accurate network planning for multiple packet transmissions.

In a multi-hop IAB network, the backhaul links are the bottleneck of the transmission setup. As an example, the IAB node directly connected to the fiber-connected IAB donor node is the most loaded node of the network which needs to transmit/receive messages of its associated CPEs as well as all other IAB nodes. This leads to high end-to-end and scheduling delay for the last hops of the network. The problem becomes emphasized in the cases with failed message transmission in the heavily-loaded nodes, as the spectrum is used for re-transmissions such as multiple hybrid automatic repeat (HARQ)-based retransmissions. This is specially because the IAB networks are mostly designed for, e.g., fixed wireless access (FWA) networks, with stationary nodes which suffer from low network diversity and require many retransmissions in case a message transmission fails.

For these reasons and to support a large number of hops and/or CPEs-per-hop, it is desired to have smart data transmission schemes such that not only the load of the highly-loaded IAB nodes is reduced but also the spectrum underutilization of the other nodes is avoided and the network diversity increases.

SUMMARY

It is an object of the present disclosure to provide a node in a wireless communication system which communicate with at least one other node, where it is desired that the load of highly-loaded nodes is reduced, and that spectrum underutilization of the other nodes is avoided.

This object is obtained by means of a node in a wireless communication system, wherein the node is adapted to communicate with at least two other nodes in the wireless communication system, where the other nodes are first type nodes which are adapted to communicate with each other by means of backhaul communication. The node is further adapted to receive a signal transmitted from an adjacent first type node, where the signal has been forwarded from at least one farther first type node. In case of unsuccessful decoding of the signal, the node is adapted to request re-transmission (NACK) of the signal, and to receive a re-transmission of the signal directly from a farther first type node.

In this way, the load and buffer requirement of the adjacent first type node is reduced, and consequently the scheduling delay is reduced as well because part of the data is transferred without using the adjacent first type node. Re-transmission is performed without any system cost in terms of spectrum and scheduling delay, where network diversity is increased and, consequently, the probability of requiring multiple retransmission rounds is reduced.

According to some aspects, the node is adapted to send a request for re-transmission of the signal directly to a farther first type node.

In this way, the adjacent first type node is not involved in handling the signal after the initial transmission to the node.

According to some aspects, the node is a first type node that is adapted to communicate with the adjacent first type node over a corresponding backhaul channel, and to communicate with said farther first type node via a direct backhaul channel.

This means that the present disclosure is applicable for backhaul communication between access points. Using a direct backhaul channel alleviates all burden from the adjacent first type node after the initial transmission to the node.

According to some aspects, the farther first type node is a first type node that is connected to a core network by means of a fiber connection.

According to some aspects, the node is a second type node that is adapted to communicate with the adjacent first type node over a corresponding access channel, and to communicate with said farther first type node via a via a direct access channel.

This means that a second type node such as a CPE initially can communicate with an adjacent first type node such as an access point, and receive possible retransmissions directly from a farther first

type node. Using a direct access channel between the second type node and the farther first type node alleviates all burden from the adjacent first type node after the initial transmission to the node.

According to some aspects, the communication between the first type nodes is a backhaul communication via at least one corresponding backhaul channel, and where at least one first type node is adapted to communicate with a corresponding group of second type nodes via a corresponding access channel. Each group of second type nodes comprises at least one second type node, where the backhaul communication and the access communication both are performed by means of common equipment at each one of the first type nodes.

This means that the present disclosure is applicable for backhaul communication between access points and CPE:s in an IAB network.

According to some aspects, a re-transmission of the signal are issued in temporarily inactive time periods where the node and the farther node are not engaged in any communication with other nodes.

This leads to lower end-to-end transmission delay, reduced buffer requirement and higher throughput for the second type nodes that are served by the node

According to some aspects, the request for re-transmission (NACK) of the signal is based on Hybrid Automatic Repeat Request (HARQ).

This object is also obtained by means of a first type node in a wireless communication system, where the first type node is adapted to communicate with at least two other nodes in the wireless communication system. At least one of the other nodes is a first type node that is adapted to communicate with other first type nodes by means of backhaul communication. The node is further adapted to receive a signal transmitted from an adjacent first type node, and to forward the signal to a receiving node. The first type node is adapted to delete the forwarded signal from its buffer after having forwarded the signal, irrespective of if the receiving node is able to decode the signal or not.

In this way, the load and buffer requirement of the first type node is reduced, and consequently the scheduling delay is reduced as well because part of the data is transferred without involving the first type node. Re-transmission is performed without any system cost in terms of spectrum and scheduling delay, where network diversity is also increased and, consequently, the probability of requiring multiple retransmission rounds is reduced.

According to some aspects, the adjacent first type node is connected to a core network by means of a fiber connection.

This object is also obtained by means of methods and a communication system that are associated with the above advantages.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure will now be described more in detail with reference to the appended drawings, where:

Figure 1 schematically shows a view of a wireless communication system according to a first example at a first time;

Figure 2 schematically shows a view of a wireless communication system according to the first example at a second time;

Figure 3 schematically shows a view of a wireless communication system according to the first example at a following time slot;

Figure 4 schematically shows a timing diagram for the wireless communication system in Figure 3;

Figure 5 schematically shows a view of a wireless communication system according to a first example at a first time;

Figure 6 schematically shows a view of a wireless communication system according to the first example at a second time;

Figure 7 shows a flowchart of methods according to embodiments;

Figure 8 shows a flowchart of methods according to embodiments;

Figure 9A schematically shows a first type node;

Figure 9B schematically shows a first type node; and

Figure 10 schematically shows a graphical representation of accumulated SNR.

DETAILED DESCRIPTION

Aspects of the present disclosure will now be described more fully hereinafter with reference to the accompanying drawings. The different devices, systems, computer programs and methods disclosed herein can, however, be realized in many different forms and should not be construed as being limited to the aspects set forth herein. Like numbers in the drawings refer to like elements throughout.

The terminology used herein is for describing aspects of the disclosure only and is not intended to limit the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise.

Network densification takes advantage of wireless backhaul; due to a relatively high installation cost of fiber links, as well as traffic jams and infrastructure displacements, the relatively small application points (APs) need to be supported by high-rate LOS wireless backhaul links which motivates so-called integrated access and backhaul (IAB) networks.

With reference to Figure 1, there is a wireless communication system 1 comprising an IAB network 7 with four hops. There are first type nodes AP_0, AP_1, AP_2, AP_3 in the wireless communication system 1, here in the form of a first access point AP_0, a second access point AP_1 a third access point AP_2 and a fourth access point AP_3. The access points AP_0, AP_1, AP_2, AP_3 are arranged for communication with each other in the wireless communication system 1 over a corresponding first backhaul channel H_1, second backhaul channel H_2, and third backhaul channel H_3 having a certain channel quality, generally by means of one of at least one type of signal relaying that according to some aspects employs decoding and encoding. According to some aspects, the signal relaying is constituted by decoding-encoding forward, DF, relaying of a signal.

Each access point AP_0, AP_1, AP_2 AP_3 is adapted for access communication with a corresponding group of second type nodes U_{01}, $U_{02;}U_{11}$, $U_{12;}U_{21}$, $U_{22;}U_{31}$, U_{32} via a corresponding access channel h_{01}, h_{02}; h_{11}, $h_{12;}h_{21}$, $h_{22;}h_{31}$, h_{32}, providing wireless access. The second type nodes U_{01}, $U_{02;}U_{11}$, $U_{12;}U_{21}$, $U_{22;}U_{31}$, U_{32} are here in the form of customer-premises equipments (CPE:s), and generally each group of CPE:s U_{01}, $U_{02;}U_{11}$, $U_{12;}U_{21}$, $U_{22;}U_{31}$, U_{32} comprises at least one CPE. The number of CPE:s for each access point AP_0, AP_1, AP_2 AP_3 in Figure 1 is only an example; there can be any number of CPE:s for each access point AP_0, AP_1, AP_2 AP_3. One or more access points can according to some aspects lack CPE:s to serve, only serving as relaying nodes. Generally, a network with N access points and m CPE:s per access point. Also, the CPE:s served by AP_i are generally denoted by $U_{ij}, j = 1, \dots, m$.

The backhaul communication and the access communication are according to some aspects both performed by means of common equipment at the access points AP_0, AP_1, AP_2 AP_3. The second access point AP_1, the third access point AP_2 and the fourth access point AP_3 are wirelessly backhauled by the first access point AP_0 connecting to a core network 2 using a fiber connection 5. An access point AP_0 connected to a core network can be referred to as an IAB donor node.

In IAB networks, uplink (UL) and downlink (DL) transmission do not follow the common definition, as both endpoints of the backhaul links are access points. However, for simplicity, we refer to data transmission towards (resp. from) the first access point AP_0 as UL (resp. DL) transmission. The present disclosure is applicable for DL transmission from the first access point AP_0 to the other nodes.

Different scheduling protocols can be considered, and in the following example a time slot 6, as illustrated in Figure 2, is divided into receive (Rx) and transmit (Tx) sub-slots RX_s, TX_s for the first access point AP_0, and in each one there is both backhaul and access connections. this means that the discussions relate to both UL transmission from the CPE:s U_{01}, $U_{02;}$ U_{11}, $U_{12;}$ U_{21}, $U_{22;}$ U_{31}, U_{32} to the first access point AP_0. and DL transmission from the first access point AP_0 to the CPE:s U_{01}, $U_{02;}$ U_{11}, $U_{12;}$ U_{21}, $U_{22;}$ U_{31}, U_{32}. Also, the setup is discussed for time-division multiple access (TDMA) setup. However, the same scheme can also be adapted for other resource allocation approaches such as for example frequency-division multiple access (FDMA).

As the number of hops/CPEs per hop increases, the AP:s need to transfer an aggregated data of multiple CPE:s accumulated from the previous hops. As a result, the AP-AP backhaul links are heavily loaded, which may lead to high decoding complexity/delay and buffering cost for the AP:s as well as large end-to-end transmission delay/low end-to-end throughput for the CPE:s. This becomes more and more pronounced the closer an AP is to an access point AP_0 that is connected to a core network 2.

More in detail, in a general case with m CPE:s per access point, which can be applied to the present example, for each time slot, the first access point AP_0 needs to send $2Nm$ signals for both its m CPEs, m DL and m UL signals, in access and the DL/UL backhaul signals for $(N-1)m$ CPEs of the other access points AP_1, AP_2, AP_3. Then, access point $i > 0$ needs to transfer $2(2Nm - im)$ signals in total, both access and backhaul, DL and UL. As a result, the second access point, AP_1 is the busiest node being active during the whole time slot, while the other access points AP_2, AP_3 may be off in some periods and wait for the previous hops to finish their data transmission.

This is because:

- Part of the spectrum is underutilized because different access points need to wait until the data transmission of the more loaded access points are finished, and
- The high load of the second access point AP_1 and other highly loaded nodes leads to large scheduling delay for all CPE:s.

The problem becomes more important if the data transmission in the link between the second access point AP_1 and the third access point AP_2 via the second backhaul channel H_2 fails. This is because IAB networks are mostly designed for, e.g., fixed wireless access (FWA) networks, with stationary CPE:s for which the network diversity is low. Thus, with high probability, multiple retransmissions based on HARQ (Hybrid Automatic Repeat Request) may be needed, which results in even higher scheduling delay and buffer requirement of the second access point AP_1.

A first example is illustrated in Figure 1, Figure 2, Figure 3 and Figure 4. In Figure 1 and Figure 2 only one signal is shown for reasons of clarity, while all signals during a time slot 6 are shown in Figure 3 and Figure 4, where Figure 4 shows a timing diagram that corresponds to Figure 3.

In Figure 1, a first signal x_A is transmitted from the first access point AP_0 to the second access point AP_1. In Figure 2, the first signal x_A is transmitted from the second access point AP_1 to the third access point AP_2. The third access point AP_2 is, however, unable to successfully decode the first signal x_A.

According to the present disclosure, with reference to Figure 3 and Figure 4, for example during a receive sub-slot RX_s, the third access point AP_2 is adapted to send a request for re-transmission, NACK, of the first signal x_A directly to the first access point AP_0 via a direct backhaul channel H_4 between the first access point AP_0 and the third access point AP_2. According to some aspects, the request for re-transmission, NACK, of the first signal x_A is based on HARQ. NACK can be sent in different ways, even in a totally different frequency.

This means that the third access point AP_2 does not request re-transmission from the second access point AP_1, which will alleviate the working of the second access point AP_1 which normally is heavily loaded.

During a following transmit sub-slot TX_s, the first access point AP_0 is adapted to re-transmit the first signal x_A directly to the third access point AP_2 via the direct backhaul channel H_4, and the third access point AP_2 is adapted to receive the re-transmitted first signal x_A directly from the first access point AP_0 via the direct backhaul channel H_4.

In this context, for the third access point AP_2, the second access point AP_1 is an adjacent first type node, and the first access point AP_0 is a farther first type node.

This means that after having transmitted the first signal x_A to the third access point AP_2, the second access point AP_1 is no longer involved in the further handling of the first signal x_A, which reduces the burden of the third access point AP_2. According to some aspects the first signal x_A is deleted from the buffer memory of the second access point AP_1 after the transmission of the first signal x_A. The first signal x_A is, however, retained in the buffer memory of the first access point AP_0.

When the first signal x_A has been successfully decoded by the third access point AP_2, it is forwarded to either the CPE:s U_{21}, U_{22} that are served by the third access point AP_2, or to the fourth access point AP_3, depending on the final destination for the first signal x_A.

According to some aspects, the following re-transmission of the first signal x_A is performed in time periods T_1 where the third access point AP_2 and the first access point AP_0 are not engaged in any communication with other nodes. This will be described in the following with reference to Figure 3 and Figure 4.

In the receive sub-slot RX_s, the first access point AP_0 is receiving information x_2, x_4 from its served CPE:s U_{01}, U_{02}, and information x_{18} from the second access point AP_1. The second access point AP_1 transmits information x_{20} to the third access point AP_2, the information x_{18} to the first access point AP_0 and information x_5, x_7 to its served CPE:s U_{11}, U_{12}. The third access point AP_2 receives the information x_{20} from the second access point AP_1, information x_{22} from the fourth access point AP_3 and information x_{10}, x_{12} from its served CPE:s U_{21}, U_{22}. The fourth access point AP_3 transmits the information x_{22} to the third access point AP_2, and information x_{14}, x_{16} to its served CPE:s U_{31}, U_{32}.

In the transmit sub-slot TX_s, the first access point AP_0 is transmitting information x_1, x_3 to its served CPE:s U_{01}, U_{02}, and information x_{17} to the second access point AP_1. The second access point AP_1 receives information x_{19} from the third access point AP_2, the information x_{17} from the first access point AP_0 and information x_6, x_8 from its served CPE:s U_{11}, U_{12}. The third access point AP_2 transmits the information x_{19} to the second access point AP_1, information x_{21} to the fourth access point AP_3 and information x_9, x_{11} to its served CPE:s U_{21}, U_{22}. The fourth access point AP_3 receives the information x_{21} from the third access point AP_2, and information x_{13}, x_{15} from its served CPE:s U_{31}, U_{32}.

Furthermore, in accordance with the present disclosure, the first access point AP_0 can take advantage of a first time period T_1 in the transmit sub-slot TX_s, when the first access point AP_0 and the third access point AP_2 are temporarily inactive, to re-transmit the first signal x_A to the third access point AP_2. The re-transmission takes place via the direct backhaul channel H_4 between the first access point AP_0 and the third access point AP_2.

Temporarily inactive time periods T_1 of different hops can thus be used to reduce network end-to-end transmission delay as well as buffer requirement.

The present disclosure will now be discussed more in detail for the present example.

By means of the present disclosure, to reduce the buffer requirement of the second access point AP_1 and reduce the scheduling delay, the second access point AP_1 is only responsible for the initial transmission of the first signal x_A to the third access point AP_2. Then, immediately after initial transmission, the second access point AP_1 drops the first signal x_A and does not wait for the acknowledgement/negative acknowledgement (ACK/NACK) from the third access point AP_2. That is, in terms of HARQ-based retransmissions, the second access point AP_1 is only responsible for the retransmissions to its own CPEs, i.e., $U_{1j}, j = 1, \ldots, m$ and not for the signals of the third access point AP_2 or the fourth access point AP_3.

Receiving the initial first signal x_A from the second access point AP_1, the third access point AP_2, tries to decode the received first signal x_A. If the first signal x_A is correctly decoded, the third access point AP_2 sends an ACK to the first access point AP_0, and then the first access point AP_0 drops the associated buffered first signal x_A. Otherwise, the third access point AP_2 sends an NACK to the first access point AP_0. Then, the HARQ-based retransmission starts where the first access point AP_0 uses temporarily inactive time periods, e.g., the time period T_1 in Figure 4, to retransmit the signal directly to the third access point AP_2. The retransmissions continues until the signal is correctly decoded or a maximum number of retransmissions, suitably considered by the network designer, is reached. Note that the second access point AP_1 is completely bypassed during the retransmission rounds and the first access point AP_0 connects to the third access point AP_2 directly.

When and how to send the ACK/NACK to the first access point AP_0 can differ. In this example, once second access point AP_1 has transmitted the initial first signal x_A, it is removed from its buffer and the second access point AP_1 does not care anymore if the third access point AP_2 can decode first signal x_A or not. Then, for possible retransmissions, the third access point AP_2 communicates directly with the first access point AP_0, both for retransmissions and ACK/NACK feedbacks via the direct backhaul channel H_4. Preferably the retransmission of signal from AP_0 to AP_2 are according to some aspects performed in temporarily inactive time periods T_1 because they often are costly and relatively long signals. The ACK/NACK is normally relatively short and not costly and can be transmitted in the same or a different frequency band.

When sending the first signal x_A to the third access point AP_2 via the second access point AP_1, the first access point AP_0 buffers the first signal x_A. Then, the first access point AP_0 waits for ACK/NACK feedbacks from the third access point AP_2, and if the third access point AP_2 fails to decode the first signal x_A from the initial data transmission of the second access point AP_1, the first access point AP_0 will take care of the retransmissions to the third access point AP_2 in the temporarily inactive time periods. Compared to data transmission in the $AP_0 – AP_1$ link, the first access point AP_0 may adapt the transmission power/rate and use a different beamforming scheme when retransmitting the failed first signal x_A directly to the third access point AP_2 in the temporarily inactive time periods. Also, the timings are adapted depending on if the second access point AP_1 or the third access point AP_2 are receiving signals from the first access point AP_0.

The AP-AP links are stationary and the second access point AP_1 can determine the appropriate transmission rate/power with high accuracy such that the third access point AP_2 can decode a received signal correctly with high probability. Therefore, the retransmission may be required rarely. Thus, considering the high load of the second access point AP_1, it is mostly not necessary that the second access point AP_1 buffers all signals to the third access point AP_2 for the rare cases of requiring retransmissions. On the other hand, due to accurate parameter adaptation, if the third access point AP_2 fails to decode a received signal, a successfully decoded signal is normally almost obtained and the third access point AP_2 only needs a small boost to decode the failed signal. This small boost can be well provided by the first access point AP_0 via the direct backhaul channel H_4 even if the link via the direct backhaul channel H_4 may be weak.

This is illustrated in Figure 10, where it is shown that a large part of the SNR required by the third access point AP_2 for successful message decoding is provided by the initial transmission of the first signal x_A from the second access point AP_1. The third access point AP_2 fails to decode the first signal x_A in a first transmission 10, since the SNR falls below a threshold γ for successful decoding. A re-transmission 11 results in that the SNR exceeds the threshold γ for successful

decoding. Since the first signal x_A in the first transmission 10 is relatively close to the threshold γ for successful decoding, in the re-transmission only a relatively small boost of the SNR is needed to exceed the threshold γ for successful decoding.

In this way, the load and buffer requirement of the second access point AP_1 is reduced, and consequently the scheduling delay is reduced as well because part of the data is transferred without using the second access point AP_1.

Re-transmission, for example using HARQ, is performed without any system cost in terms of spectrum and scheduling delay where spectrum utilization is improved by using the temporarily inactive time periods T_1. Performing the initial transmission via the second backhaul channel H_2 and retransmissions via the direct backhaul channel H_4 increases the network diversity and, consequently, reduces the probability of requiring multiple HARQ-based retransmission rounds.

Moreover, the spectrum utilization is improved by using the temporarily inactive time periods T_1, which leads to lower end-to-end transmission delay and higher throughput for the CPE:s U_{21}, U_{22}; U_{31}, U_{32} that are served by the third access point AP_2 and the fourth access point AP_3.

According to some aspects, the third access point AP_2 sends an ACK/NACK, in dependence of if the decoding has been successful or not, to the to the first access point AP_0 via the first access point AP_1, via the second backhaul channel H_2 and the first backhaul channel H_1, not via the direct backhaul channel H_4. The re-transmitted signal x_A is always transmitted via the direct backhaul channel H_4. This is a possible aspect, since the ACK/NACK signal contains relatively little information and contributes relatively little to the load of an AP compared to a normal data message. This can be applicable for all examples and other possible signal routes.

With reference to Figure 5 and Figure 6, a second example is provided. Here, only one signal is shown for reasons of clarity.

In Figure 5, two instances in time are shown. First, a first signal x_A is transmitted from the first access point AP_0 to second access point AP_1, and then from the second access point AP_1 to a first CPE U_{11} that is served by the second access point AP_1. The first CPE U_{11} is, however, unable to successfully decode the first signal x_A.

According to the present disclosure, with reference to Figure 6, the first CPE U_{11} is adapted to send a request for re-transmission, NACK, of the first signal x_A directly to the first access point AP_0 via a direct access channel h_{13} between the first access point AP_0 and first CPE U_{11}. According to some aspects, the request for re-transmission, NACK, of the signal x_A is based on HARQ.

This means that the first CPE U_{11} does not request re-transmission from the second access point AP_1, which will alleviate the working of the second access point AP_1 which normally is heavily loaded.

The first access point AP_0 is adapted to re-transmit the first signal x_A directly to the first CPE U_{11} via the direct access channel h_{13}, and the first CPE U_{11} is adapted to receive the re-transmitted first signal x_A directly from the first access point AP_0 via the direct access channel h_{13}.

In this context, for the first CPE U_{11}, the second access point AP_1 is an adjacent first type node, and the first access point AP_0 is a farther first type node.

The present disclosure can thus be implemented for both backhaul communication and access communication.

By means of the present disclosure, scheduling and end-to-end data transmission delays are reduced, network diversity is increased, buffer requirement of the AP nodes is reduced, and different AP nodes of the network will have an equalized load which leads to better balance of the load in different AP nodes. Particularly, the load/buffer requirement of the most loaded AP nodes, in the examples above the second application point AP_1, is reduced and spectrum utilization of low-loaded nodes as well as the network diversity are increased, such that spectrum underutilization of low-loaded nodes is avoided.

The temporarily inactive time periods of the AP nodes with low spectrum utilization are used for HARQ-based retransmissions, in case the data transmission in the heavily-loaded links fails, which increases the network diversity and reduces the probability of requiring multiple HARQ-based retransmissions. As a further result, the heavily-loaded nodes are not responsible for HARQ-based retransmissions, and can drop the message from their buffer after the first transmission. Also, depending on the data transmission method in different time slots, the timing, the beamforming and the buffering methods of the IAB nodes are updated. In this way, this leads to improved end-to-end throughput of the CPE:s, better energy efficiency, and decreased buffer requirement for the AP nodes.

As a result of this, the number of hops and/or the number of CPE:s per hop can be increased.

With reference to Figure 7, the present disclosure also relates to a method in a node AP_2, U_{11} in a wireless communication system 1, wherein the method comprises communicating S1 with at least two other nodes AP_1, AP_0 in the wireless communication system 1, where the other nodes AP_1, AP_0 are of a first type and constitute first type nodes AP_1, AP_0 that use backhaul communication when communicating with each other. The method further comprises receiving S2 a signal x_A transmitted from an adjacent first type node AP_1, where the signal x_A has been forwarded from at least one farther first type node AP_0. In case of unsuccessful decoding S3 of the signal x_A, the method comprises requesting S4 re-transmission NACK of the signal x_A and receiving S5 re-transmission of the signal x_A directly from a farther first type node AP_0.

According to some aspects, the method comprises sending S41 a request for re-transmission NACK of the signal x_A directly to a farther first type node AP_0.

According to some aspects, the node is a first type node AP_2 that is used for communication with the adjacent first type node AP_1 over a corresponding backhaul channel H_1, and for communication with said farther first type node AP_0 via a via a direct backhaul channel H_4.

According to some aspects, the farther first type node is a first type node AP_0 that is connected to a core network 2 by means of a fiber connection 5.

According to some aspects, the node is a second type node U_{11} that is used for communication with the adjacent first type node AP_1 over a corresponding access channel h_{11}, and for communication with said farther first type node AP_0 via a via a direct access channel h_{13}.

According to some aspects, the communication between the first type nodes AP_0, AP_1, AP_2, AP_3 is a backhaul communication via at least one corresponding backhaul channel H_1, H_2, H_3, H_4, and where at least one first type node AP_0, AP_1, AP_2, AP_3 is used for communication with a corresponding group of second type nodes U_{11}, $U_{12;}$ U_{21}, $U_{22;}$ U_{31}, U_{32} via a corresponding access channel h_{11}, $h_{12;}$ h_{21}, $h_{22;}$ h_{31}, h_{32}. Each group of second type nodes U_{11}, $U_{12;}$ U_{21}, $U_{22;}$ U_{31}, U_{32} comprises at least one second type node U_{11}, $U_{12;}$ U_{21}, $U_{22;}$ U_{31}, U_{32}, where the backhaul communication and the access communication both are performed by means of common equipment at each one of the first type nodes AP_0, AP_1, AP_2, AP_3.

According to some aspects, the method comprises re-transmission of the signal x_A in temporarily inactive time periods T_1 where the node AP_2 and the farther node AP_0 are not used for communication with other nodes.

According to some aspects, the request for re-transmission NACK of the signal x_A is based on Hybrid Automatic Repeat Request (HARQ).

With reference to Figure 8, the present disclosure also relates to a method in a first type node AP_1 in a wireless communication system 1, wherein the method comprises communicating T1 with at least two other nodes AP_2, U_{11}, AP_0 in the wireless communication system 1, where at least one of the other nodes AP_2, AP_0 is a first type node that uses backhaul communication when communicating with other first type nodes, and receiving T2 a signal x_A transmitted from an adjacent first type node AP_0. The method further comprises forwarding T3 the signal x_A to a receiving node AP_2, U_{11}, and deleting T4 the forwarded signal x_A from its buffer after having forwarded the signal x_A, irrespective of if the receiving node AP_2, U_{11} is able to decode the signal x_A or not.

According to some aspects, the adjacent first type node AP_0 is connected to a core network 2 by means of a fiber connection 5.

As shown in Figure 9A, according to some aspects, a node AP_2, U_{11}, in a wireless communication system 1 comprises a processor unit 3 that is adapted to control communication with at least two other first type nodes AP_1, AP_0 in the wireless communication system 1. The processor unit 3 is further adapted to control reception of a signal x_A transmitted from an adjacent first type node AP_1, where the signal x_A has been forwarded from at least one farther first type node AP_0. In case of unsuccessful decoding of the signal x_A, the processor unit 3 is further adapted to request re-transmission (NACK) of the signal x_A; and to control reception of a re-transmission of the signal x_A directly from a farther first type node AP_0.

According to some aspects, the processor unit 3 is adapted to control a sending of a request for re-transmission (NACK) of the signal x_A directly to a farther first type node AP_0.

According to some aspects, the node is a first type node AP_2 that is adapted to communicate with the adjacent first type node AP_1 over a corresponding backhaul channel H_1, and to communicate with said farther first type node AP_0 via a via a direct backhaul channel H_4.

According to some aspects, the farther first type node is a first type node AP_0 that is connected to a core network 2 by means of a fiber connection 5.

According to some aspects, the node is a second type node U_{11} that is adapted to communicate with the adjacent first type node AP_1 over a corresponding access channel h_{11}, and to communicate with said farther first type node AP_0 via a via a direct access channel h_{13}.

As shown in Figure 9B, according to some aspects, a first type node AP_1 in a wireless communication system 1 comprises a processor unit 4 that is adapted to control communication with at least two other first type nodes AP_2, U_{11}, AP_0 in the wireless communication system ,where at least one of the other nodes AP_2, AP_0 is a first type node that is adapted to communicate with other first type nodes by means of backhaul communication. The processor unit 4 is further adapted to control reception of a signal x_A transmitted from an adjacent first type node AP_0, and to forward the signal x_A to a receiving node AP_2, U_{11}. The processor unit 3 is further adapted to delete the forwarded signal x_A from a buffer memory after transmission of the signal x_A, irrespective of if the receiving node is able to decode the signal x_A or not.

According to some aspects, the adjacent first type node is a first type node AP_0 that is connected to a core network 2 by means of a fiber connection 5.

The present disclosure also relates to a wireless communication system 1 comprising an integrated access and backhaul, IAB, network 7 which in turn comprises the nodes AP_2, U_{11}; AP_1 discussed above with reference to Figure 9A and Figure 9B.

The present disclosure is not limited to the above, but may vary freely within the scope of the appended claims. For example, in the examples discussed above, the first access point AP_0 connects to the third access point AP_2 directly to provide it with the signals of the served CPE:s U_{21}, U_{22}; U_{31}, U_{32} of both the third access point AP_2 and the fourth access point AP_3. However, according to some aspects, the first access point AP_0 is adapted to directly receive a NACK for a certain signal from any access point that is not closest to the first access point AP_0, for example directly from the fourth access point AP_3. The first access point AP_0 is then adapted to directly re-transmit said certain signal to any access point that is not closest to the first access point AP_0, for example directly to the fourth access point AP_3 in a second time period T_2 where the first access point AP_0 and the fourth access point AP_3 are temporarily inactive.

In the examples discussed above, a time slot 6 is divided into sub-slots RX_s, TX_s, each one having access and backhaul connections. In another approach, a time slot is divided into access and backhaul sub-slots where each one has DL and UL transmission. Generally, the present disclosure is applicable for different schemes of time allocation.

According to some aspects, the efficiency of the present disclosure depends on the amount of interference added to the access links between the second access point AP_1 and its served CPE:s U_{11}, U_{12} by means of the direct transmission from, for example, the first access point AP_0 to the third access point AP_2 . However, because the AP:s normally are equipped with many antennas and advanced beamforming methods, and also because the direct communication via the direct channel H_4 does not need to have high rate and, consequently, possibly relatively low transmission power, the interference to the access links between the second access point AP_1 and its served CPE:s U_{11}, U_{12} will be negligible. This is especially because an IAB network normally is used for stationary networks where the channel measurements and parameter settings can be done before the data transmission.

According to some aspects, examples of important parts of the present disclosure are:

1) As discussed previously, present disclosure is applicable for setting up a direct channel between two nodes such that one node is bypassed and relieved. For example, the fourth access point AP_3 can communicate directly with the first access point AP_0 via a corresponding direct backhaul channel.

2) In the examples described, a time slot is divided into RX/TX sub-slots RX_s, TX_s, each one having access and backhaul connections. In another approach, the time slot is divided into access and backhaul sub-slots each one having DL and UL transmission. The present disclosure is applicable for different schemes of time allocation.

3) The efficiency of the proposed method depends on if a fairly good direct backhaul channel H_4 can be found. However, because a large part of the minimum SNR required for successfully decoding has been provided by the initial transmission of the signal x_A as shown in Figure 10, lower data rates can be used for the direct backhaul channel H_4 without affecting end-to-end data transmission delay.

According to some aspects, the present disclosure can easily extended to the cases with arbitrary number of hops, different relaying approaches or star-like network configuration.

According to some aspects, in the present context, the term signal corresponds to a data signal or a data message. According to some aspects, in the present context, the terms relay and relaying correspond to the terms forward and forwarding.

According to some aspects, the node AP_2, U_{11} that sends a request for re-transmission, NACK, of the signal x_A, can either send directly to the first access point AP_0, or to the second access point AP_1 that forwards the NACK to the first access point AP_0.

The present disclosure has been described for an uncomplicated case with relatively few hops, although the present disclosure can be applied to the cases with arbitrary number of hops and CPE:s.

In the examples, the third access point AP_2 has been adapted to communicate directly with the first access point AP_0 via the direct backhaul channel H_4, but not the fourth access point AP_3 that has to depend on relaying via the third access point AP_2 for both uplink and downlink. According to some aspects, the fourth access point AP_3 and possibly one or more other (not shown) access points can also be adapted to communicate directly with the first access point AP_0, or other suitable access points, via corresponding direct backhaul channels.

According to some aspects, the wireless communication system 1 can be any suitable communication system that comprises any suitable wireless network. According to some aspects, the wireless communication system 1 comprises one or more IAB networks 7.

The present disclosure is applicable for both uplink (UL) and downlink (DL) transmissions as well as for different types of HARQ.

Generally, the present disclosure relates to a node AP_2, U_{11} in a wireless communication system 1, wherein the node AP_2, U_{11} is adapted to communicate with at least two other nodes AP_1, AP_0 in the wireless communication system 1, where the other nodes AP_1, AP_0 are first type nodes AP_1, AP_0 which are adapted to communicate with each other by means of backhaul communication. The node AP_2, U_{11} is further adapted to receive a signal x_A transmitted from an adjacent first type node AP_1, where the signal x_A has been forwarded from at least one farther first type node AP_0. In case of unsuccessful decoding of the signal x_A, the node AP_2, U_{11} is adapted to request re-transmission (NACK) of the signal x_A, and to receive a re-transmission of the signal x_A directly from a farther first type node AP_0.

According to some aspects, the node AP_2, U_{11} is adapted to send a request for re-transmission NACK of the signal x_A directly to a farther first type node AP_0.

According to some aspects, the node is a first type node AP_2 that is adapted to communicate with the adjacent first type node AP_1 over a corresponding backhaul channel H_1, and to communicate with said farther first type node AP_0 via a direct backhaul channel H_4.

According to some aspects, the farther first type node is a first type node AP_0 that is connected to a core network 2 by means of a fiber connection 5.

According to some aspects, the node is a second type node U_{11} that is adapted to communicate with the adjacent first type node AP_1 over a corresponding access channel h_{11}, and to communicate with said farther first type node AP_0 via a via a direct access channel h_{13}.

According to some aspects, the communication between the first type nodes AP_0, AP_1, AP_2, AP_3 is a backhaul communication via at least one corresponding backhaul channel H_1, H_2, H_3, H_4, and where at least one first type node AP_0, AP_1, AP_2, AP_3 is adapted to communicate with a corresponding group of second type nodes U_{11}, $U_{12;}$ U_{21}, $U_{22;}$ U_{31}, U_{32} via a corresponding access channel h_{11}, $h_{12;}$ h_{21}, $h_{22;}$ h_{31}, h_{32}, each group of second type nodes U_{11}, $U_{12;}$ U_{21}, $U_{22;}$ U_{31}, U_{32} comprising at least one second type node U_{11}, $U_{12;}$ U_{21}, $U_{22;}$ U_{31}, U_{32}, where the backhaul communication and the access communication both are performed by means of common equipment at each one of the first type nodes AP_0, AP_1, AP_2, AP_3.

According to some aspects, a re-transmission of the signal x_A are issued in temporarily inactive time periods T_1 where the node AP_2 and the farther node AP_0 are not engaged in any communication with other nodes.

According to some aspects, the request for re-transmission (NACK) of the signal x_A is based on Hybrid Automatic Repeat Request (HARQ).

Generally, the present disclosure also relates to first type node AP_1 in a wireless communication system 1, where the first type node AP_1 is adapted to communicate with at least two other nodes AP_2, U_{11}, AP_0 in the wireless communication system 1, where at least one of the other nodes AP_2, AP_0 is a first type node that is adapted to communicate with other first type nodes by means of backhaul communication. The first type node AP_1 is adapted to receive a signal x_A transmitted from an adjacent first type node AP_0, and toforward the signal x_A to a receiving node AP_2, U_{11}. The first type node AP_1 is adapted to delete the forwarded signal x_A from its buffer after having forwarded the signal x_A, irrespective of if the receiving node is able to decode the signal x_A or not.

According to some aspects, the adjacent first type node AP_0 is connected to a core network 2 by means of a fiber connection 5.

Generally, the present disclosure also relates to wireless communication system 1 comprising an integrated access and backhaul, IAB, network 7 which in turn comprises at least the node AP_2, U_{11} according to the above and the first type node AP_1 according to the above.

5

CLAIMS

1. A node (AP_2, U_{11}) in a wireless communication system (1), wherein the node (AP_2, U_{11}) is adapted to:

communicate with at least two other nodes (AP_1, AP_0) in the wireless communication system (1), where the other nodes (AP_1, AP_0) are first type nodes (AP_1, AP_0) which are adapted to communicate with each other by means of backhaul communication; and to

receive a signal (x_A) transmitted from an adjacent first type node (AP_1), where the signal (x_A) has been forwarded from at least one farther first type node (AP_0);

wherein, in case of unsuccessful decoding of the signal (x_A), the node (AP_2, U_{11}) is adapted to:

request re-transmission, NACK, of the signal (x_A); and to

receive a re-transmission of the signal (x_A) directly from a farther first type node (AP_0).

2. The node (AP_2) according to claim 1, wherein the node (AP_2, U_{11}) is adapted to send a request for re-transmission, NACK, of the signal (x_A) directly to a farther first type node (AP_0).

3. The node (AP_2) according to any one of the claims 1 or 2, wherein the node is a first type node (AP_2) that is adapted to communicate with the adjacent first type node (AP_1) over a corresponding backhaul channel (H_1), and to communicate with said farther first type node (AP_0) via a direct backhaul channel (H_4).

4. The node (AP_2) according to any one of the previous claims, wherein the farther first type node is a first type node (AP_0) that is connected to a core network (2) by means of a fiber connection (5).

5. The node (U_{11}) according to any one of the claims 1 or 2, wherein the node is a second type node (U_{11}) that is adapted to communicate with the adjacent first type node (AP_1) over a corresponding access channel (h_{11}), and to communicate with said farther first type node (AP_0) via a via a direct access channel (h_{13}).

6. The node (AP_2, U_{11}) according to any one of the previous claims, wherein the communication between the first type nodes (AP_0, AP_1, AP_2, AP_3) is a backhaul communication via at least one corresponding backhaul channel (H_1, H_2, H_3, H_4), and where at least one first type node (AP_0, AP_1, AP_2, AP_3) is adapted to communicate with a corresponding group of second type nodes (U_{11}, $U_{12;}$ U_{21}, $U_{22;}$ U_{31}, U_{32}) via a corresponding access channel (h_{11}, $h_{12;}$ h_{21}, $h_{22;}$ h_{31}, h_{32}), each group of second type nodes (U_{11}, $U_{12;}$ U_{21}, $U_{22;}$ U_{31}, U_{32}) comprising at least one second type node (U_{11}, $U_{12;}$ U_{21}, $U_{22;}$ U_{31}, U_{32}), where the backhaul communication and the access

communication both are performed by means of common equipment at each one of the first type nodes (AP_0, AP_1, AP_2, AP_3).

7. The node (AP_2) according to any one of the previous claims, wherein a re-transmission of the signal (x_A) are issued in temporarily inactive time periods (T_1) where the node (AP_2) and the farther node (AP_0) are not engaged in any communication with other nodes.

8. The node (AP_2, U_{11}) according to any one of the previous claims, wherein the request for re-transmission, NACK, of the signal (x_A) is based on Hybrid Automatic Repeat Request, HARQ.

9. A first type node (AP_1) in a wireless communication system (1), where the first type node (AP_1) is adapted to:

communicate with at least two other nodes (AP_2, U_{11}, AP_0) in the wireless communication system (1), where at least one of the other nodes (AP_2, AP_0) is a first type node that is adapted to communicate with other first type nodes by means of backhaul communication;

receive a signal (x_A) transmitted from an adjacent first type node (AP_0), and to

forward the signal (x_A) to a receiving node (AP_2, U_{11});

wherein the first type node (AP_1) is adapted to delete the forwarded signal (x_A) from its buffer after having forwarded the signal (x_A), irrespective of if the receiving node is able to decode the signal (x_A) or not.

10. The first type node (AP_1) according to claim 9, wherein the adjacent first type node (AP_0) is connected to a core network (2) by means of a fiber connection (5).

11. A method in a node (AP_2, U_{11}) in a wireless communication system (1), wherein the method comprises:

communicating (S1) with at least two other nodes (AP_1, AP_0) in the wireless communication system (1), where the other nodes (AP_1, AP_0) are of a first type and constitute first type nodes (AP_1, AP_0) that use backhaul communication when communicating with each other; and

receiving (S2) a signal (x_A) transmitted from an adjacent first type node (AP_1), where the signal (x_A) has been forwarded from at least one farther first type node (AP_0);

wherein, in case of unsuccessful decoding (S3) of the signal (x_A), the method comprises:

requesting (S4) re-transmission, NACK, of the signal (x_A); and

receiving (S5) re-transmission of the signal (x_A) directly from a farther first type node (AP_0).

12. The method according to claim 11, wherein the method comprises sending (S41) a request for re-transmission, NACK, of the signal (x_A) directly to a farther first type node (AP_0).

13. The method according to any one of the claims 11 or 12, wherein the node is a first type node (AP_2) that is used for communication with the adjacent first type node (AP_1) over a corresponding backhaul channel (H_1), and for communication with said farther first type node (AP_0) via a via a direct backhaul channel (H_4).

14. The method according to any one of the claims 11-13, wherein the farther first type node is a first type node (AP_0) that is connected to a core network (2) by means of a fiber connection (5).

15. The method according to any one of the claims 11 or 12, wherein the node is a second type node (U_{11}) that is used for communication with the adjacent first type node (AP_1) over a corresponding access channel (h_{11}), and for communication with said farther first type node (AP_0) via a via a direct access channel (h_{13}).

16. The method according to any one of the claims 11-15, wherein the communication between the first type nodes (AP_0, AP_1, AP_2, AP_3) is a backhaul communication via at least one corresponding backhaul channel (H_1, H_2, H_3, H_4), and where at least one first type node (AP_0, AP_1, AP_2, AP_3) is used for communication with a corresponding group of second type nodes (U_{11}, $U_{12;}$ U_{21}, $U_{22;}$ U_{31}, U_{32}) via a corresponding access channel (h_{11}, $h_{12;}$ h_{21}, $h_{22;}$ h_{31}, h_{32}), each group of second type nodes (U_{11}, $U_{12;}$ U_{21}, $U_{22;}$ U_{31}, U_{32}) comprising at least one second type node (U_{11}, $U_{12;}$ U_{21}, $U_{22;}$ U_{31}, U_{32}), where the backhaul communication and the access communication both are performed by means of common equipment at each one of the first type nodes (AP_0, AP_1, AP_2, AP_3).

17. The method according to any one of the claims 11-16, wherein the method comprises re-transmitting the signal (x_A) in temporarily inactive time periods (T_1) where the node (AP_2) and the farther node (AP_0) are not used for communication with other nodes.

18. The method according to any one of the claims 11-17, wherein the request for re-transmission, NACK, of the signal (x_A) is based on Hybrid Automatic Repeat Request, HARQ.

19. A method in a first type node (AP_1) in a wireless communication system (1), wherein the method comprises:

communicating (T1) with at least two other nodes (AP_2, U_{11}, AP_0) in the wireless communication system (1), where at least one of the other nodes (AP_2, AP_0) is a first type node that uses backhaul communication when communicating with other first type nodes;

receiving (T2) a signal (x_A) transmitted from an adjacent first type node (AP_0), and

forwarding (T3) the signal (x_A) to a receiving node (AP_2, U_{11});

wherein the method comprises

deleting (T4) the forwarded signal (x_A) from its buffer after having forwarded the signal (x_A), irrespective of if the receiving node (AP_2, U_{11}) is able to decode the signal (x_A) or not.

20. The method according to claim 19, wherein the adjacent first type node (AP_0) is connected to a core network (2) by means of a fiber connection (5).

21. A wireless communication system (1) comprising an integrated access and backhaul, IAB, network (7) which in turn comprises at least the node (AP_2, U_{11}) according to any one of the claims 1-8 and the first type node (AP_1) according to any one of the claims 9 or 10.

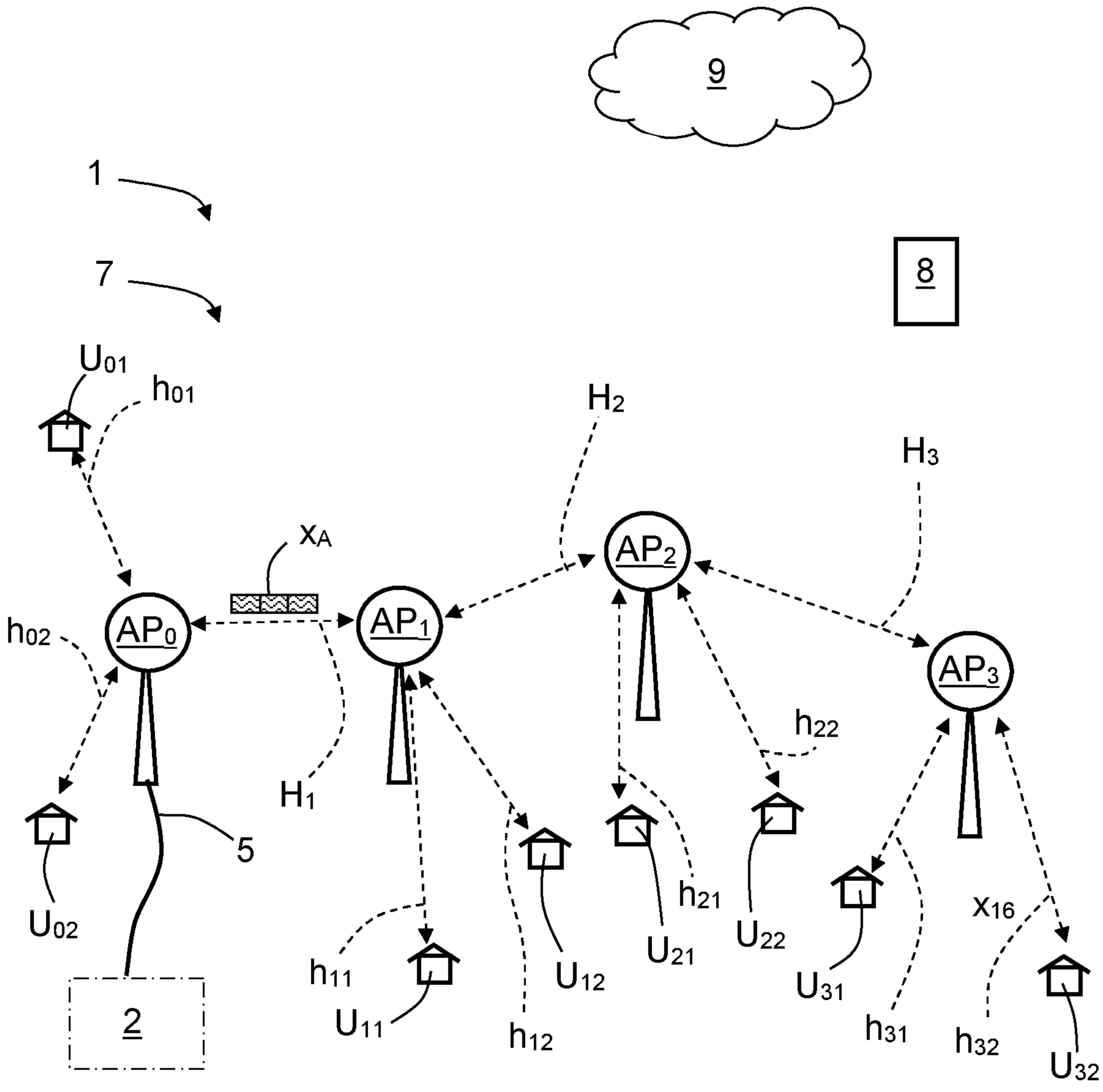

9
1
7
8
U_{01}
h_{01}
H_2
H_3
x_A
AP_0
AP_1
AP_2
AP_3
h_{02}
h_{22}
H_1
5
U_{02}
h_{21}
U_{21}
U_{22}
h_{11}
U_{11}
U_{12}
h_{12}
U_{31}
h_{31}
x_{16}
h_{32}
U_{32}
2

FIG. 1

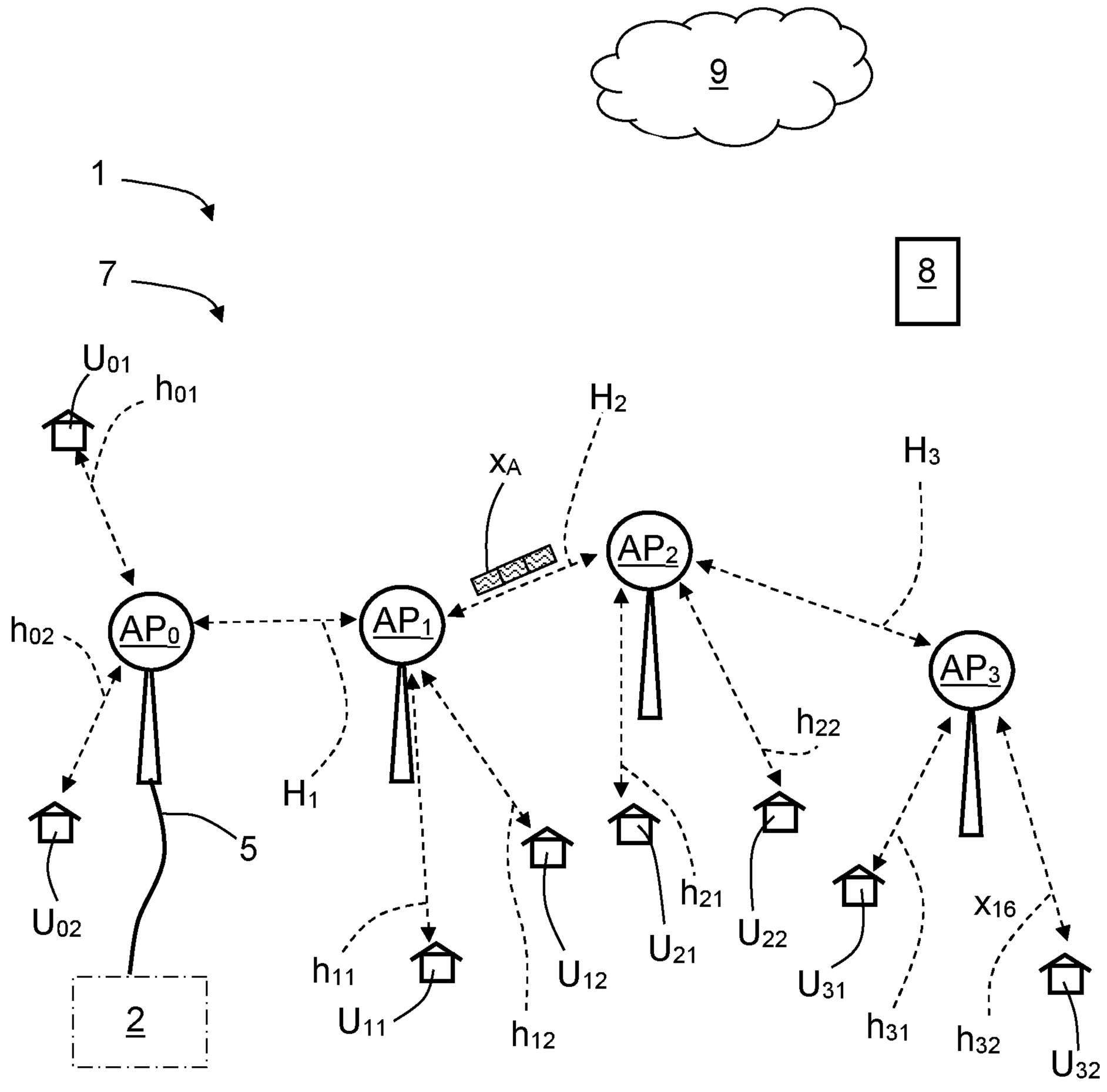

9
1
7
8
U01
h01
H2
xA
H3
AP0
AP1
AP2
AP3
h02
h22
H1
5
h21
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U12
h12
h31
h32
U32

FIG. 2

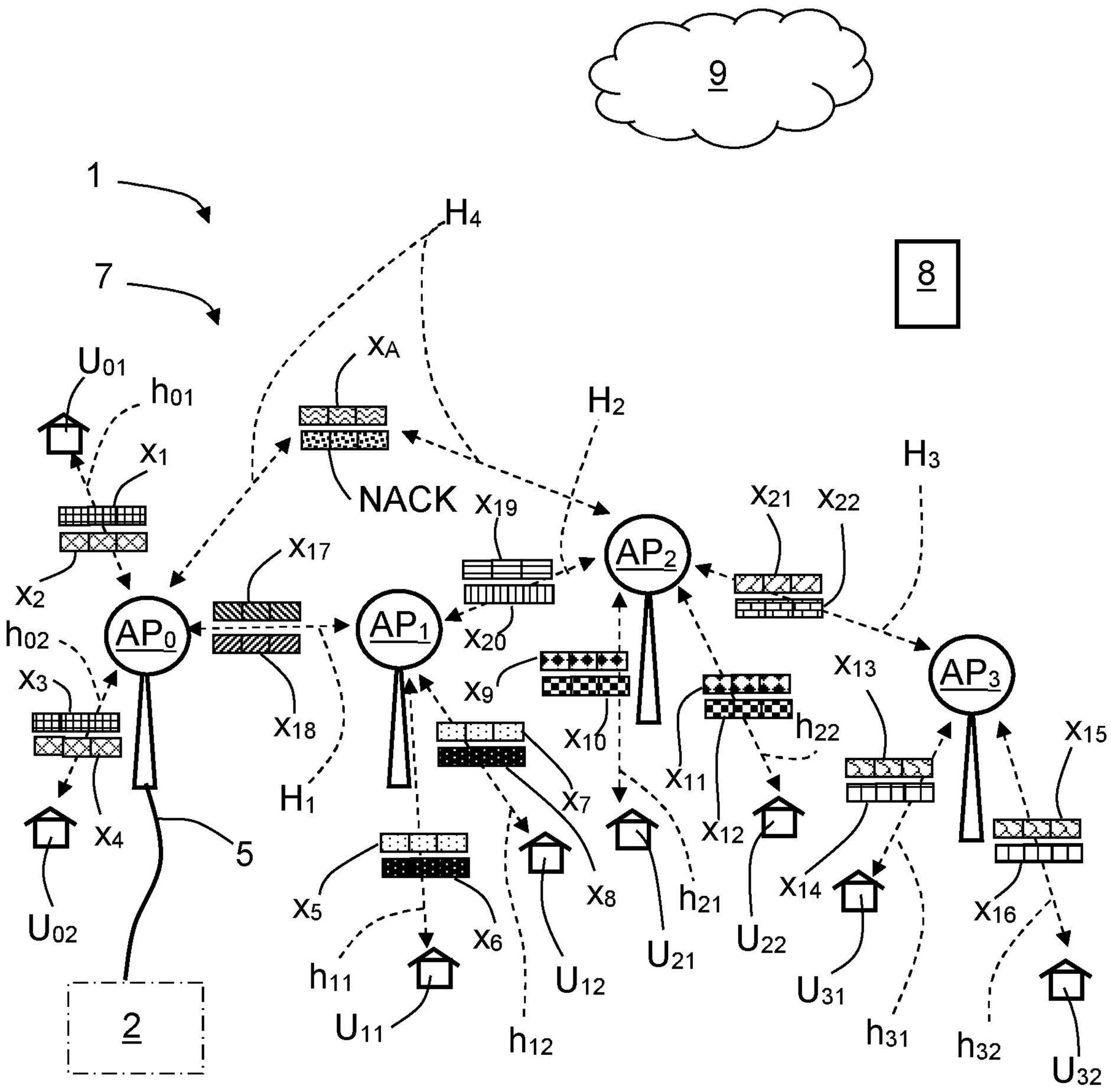

9
1
7
8
H_4
U_{01}
h_{01}
x_A
H_2
H_3
x_1
NACK
x_{19}
x_{21}
x_{22}
x_{17}
AP_2
x_2
AP_0
AP_1
AP_3
h_{02}
x_{20}
x_3
x_{18}
x_9
x_{13}
x_{10}
h_{22}
x_{11}
x_{15}
H_1
x_7
x_{12}
x_4
5
x_8
h_{21}
x_{14}
x_5
x_6
h_{11}
U_{12}
U_{21}
U_{22}
x_{16}
U_{02}
U_{31}
U_{11}
h_{12}
h_{31}
h_{32}
U_{32}
2

FIG. 3

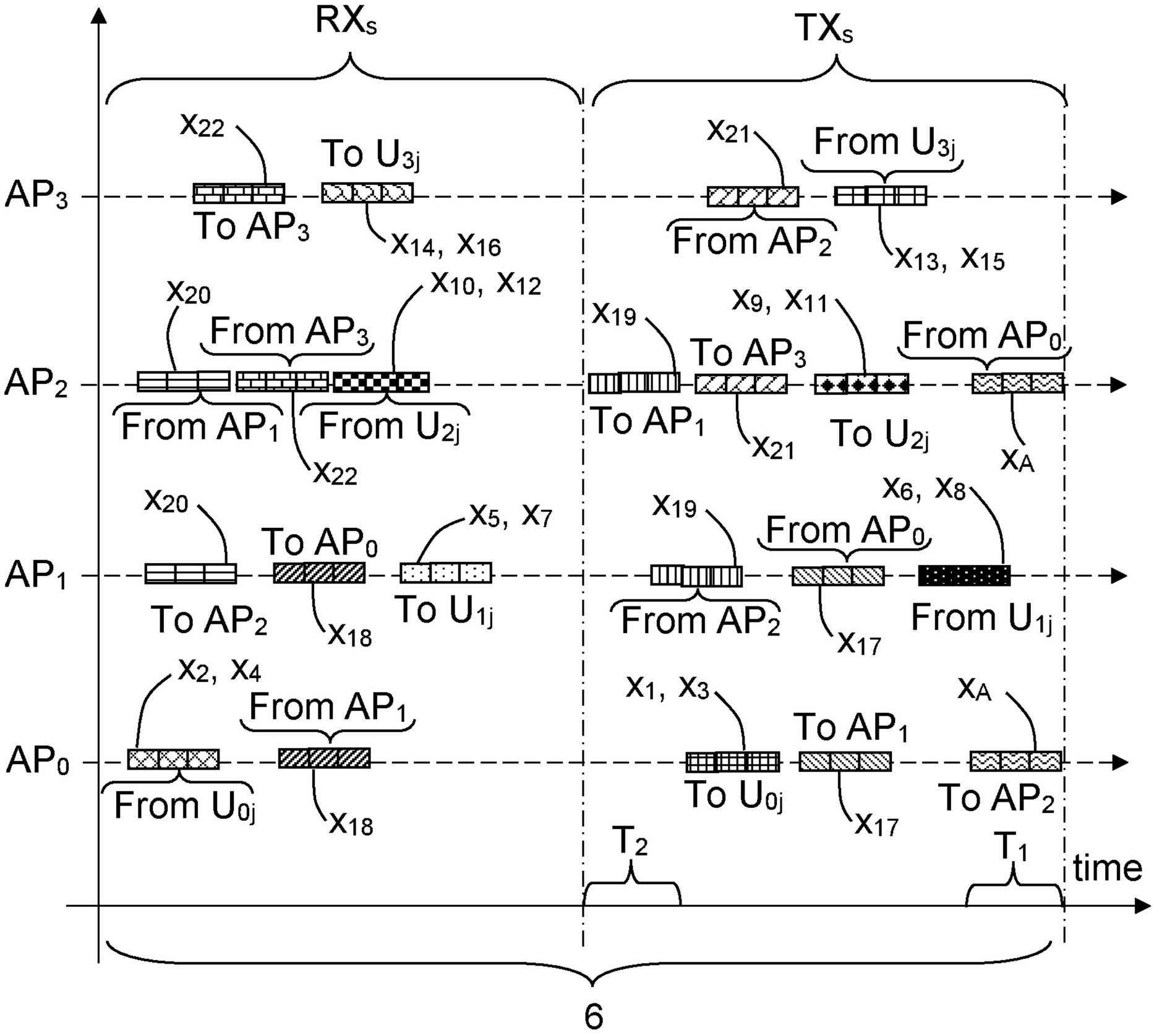

RXs
TXs
AP3
x22
To U3j
To AP3
x14, x16
x21
From U3j
From AP2
x13, x15
AP2
x20
From AP3
x10, x12
From AP1
From U2j
x22
x19
x9, x11
From AP0
To AP3
To AP1
x21
To U2j
xA
AP1
x20
To AP0
x5, x7
To AP2
x18
To U1j
x19
x6, x8
From AP0
From AP2
x17
From U1j
AP0
x2, x4
From AP1
From U0j
x18
x1, x3
To AP1
To U0j
x17
xA
To AP2
T2
T1
time
6

FIG. 4

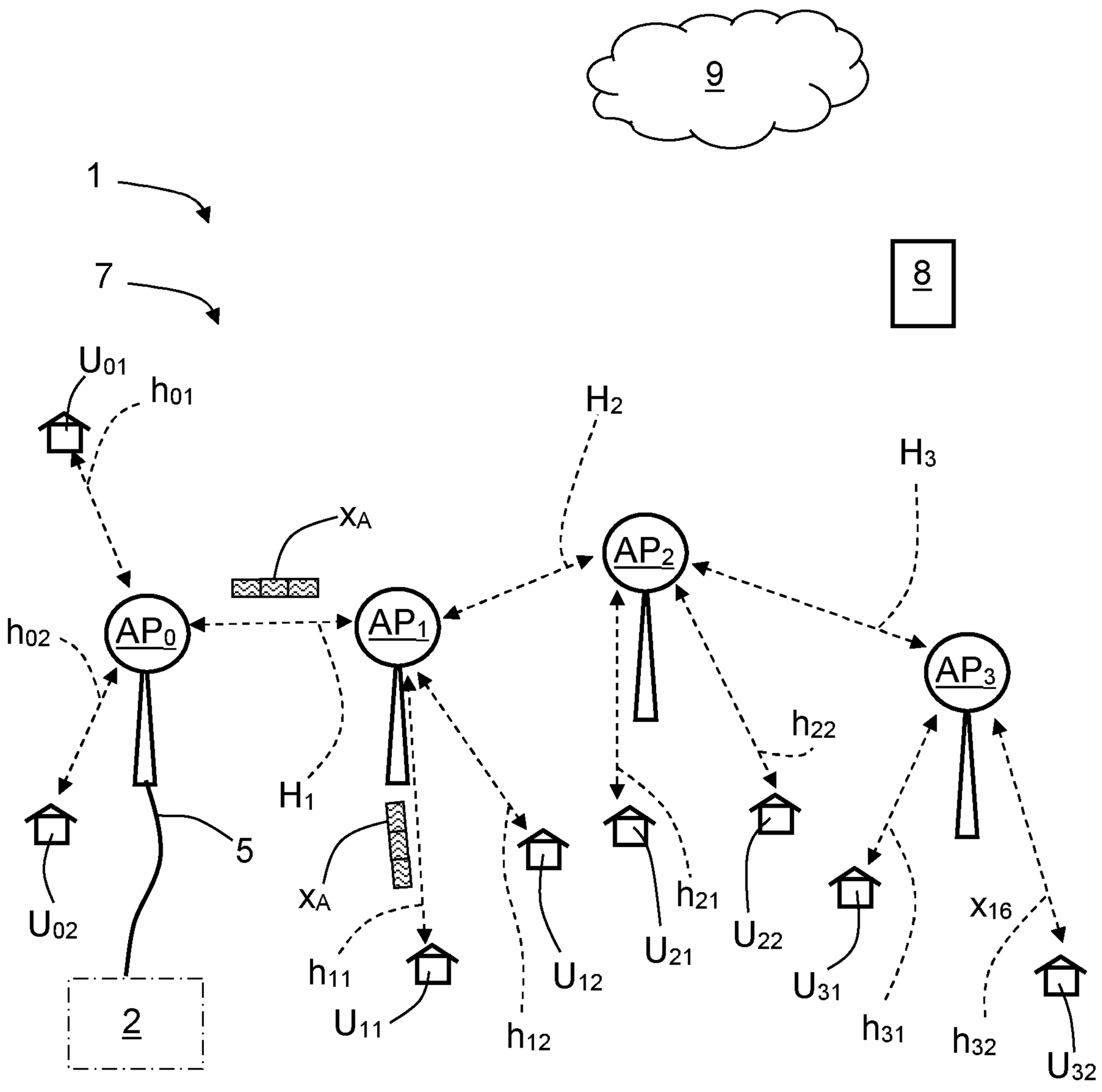

9
1
7
8
U_{01}
h_{01}
x_A
H_2
H_3
AP_0
AP_1
AP_2
AP_3
h_{02}
H_1
h_{22}
5
x_A
h_{21}
x_{16}
U_{02}
h_{11}
U_{12}
U_{21}
U_{22}
U_{31}
U_{11}
h_{12}
h_{31}
h_{32}
U_{32}
2

FIG. 5

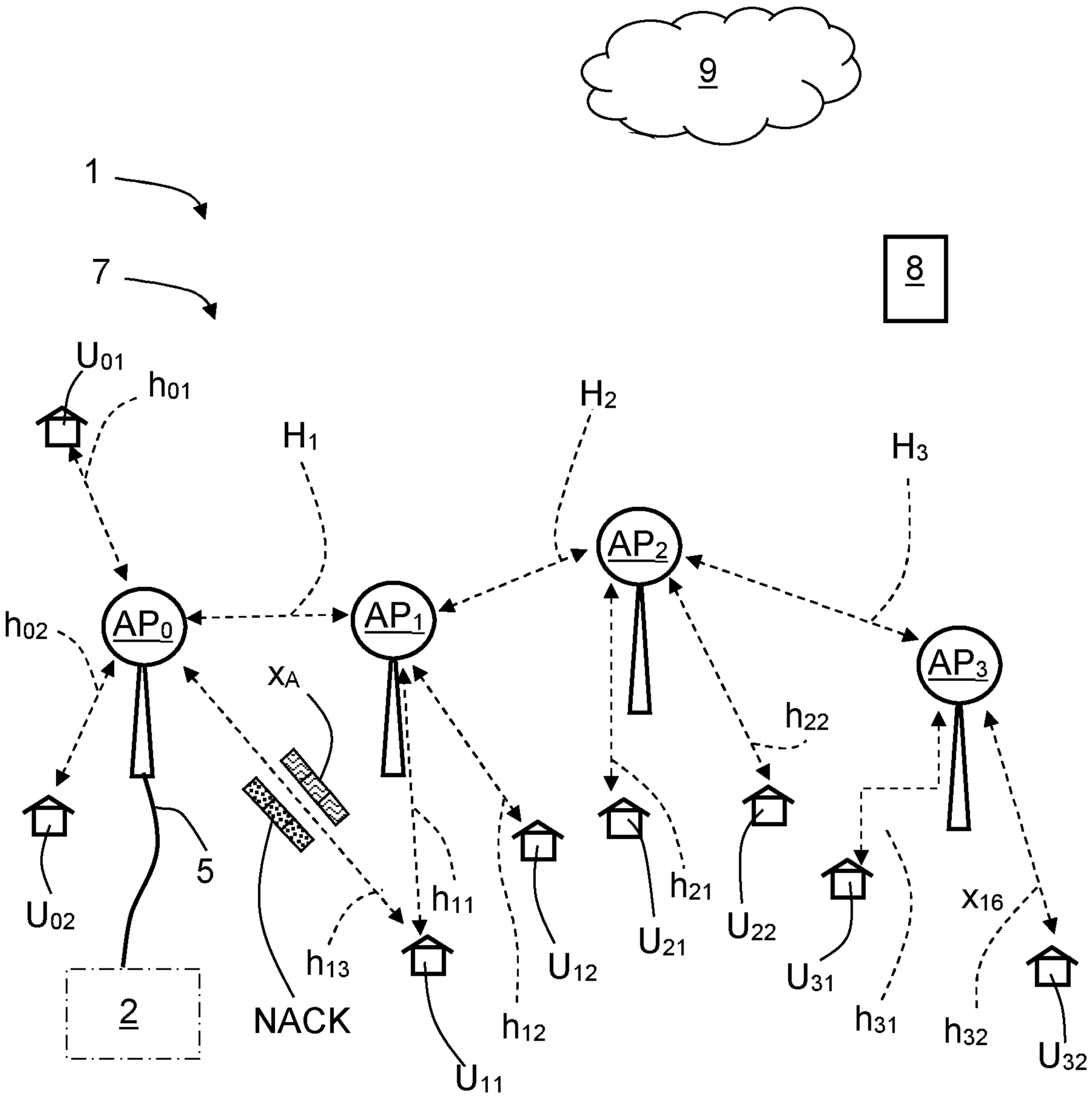

9
1
7
8
U_{01}
h_{01}
H_1
H_2
H_3
AP_0
AP_1
AP_2
AP_3
h_{02}
x_A
h_{22}
x_{16}
U_{02}
5
h_{13}
h_{11}
U_{12}
h_{21}
U_{21}
U_{22}
U_{31}
h_{31}
h_{32}
U_{32}
2
NACK
h_{12}
U_{11}

FIG. 6

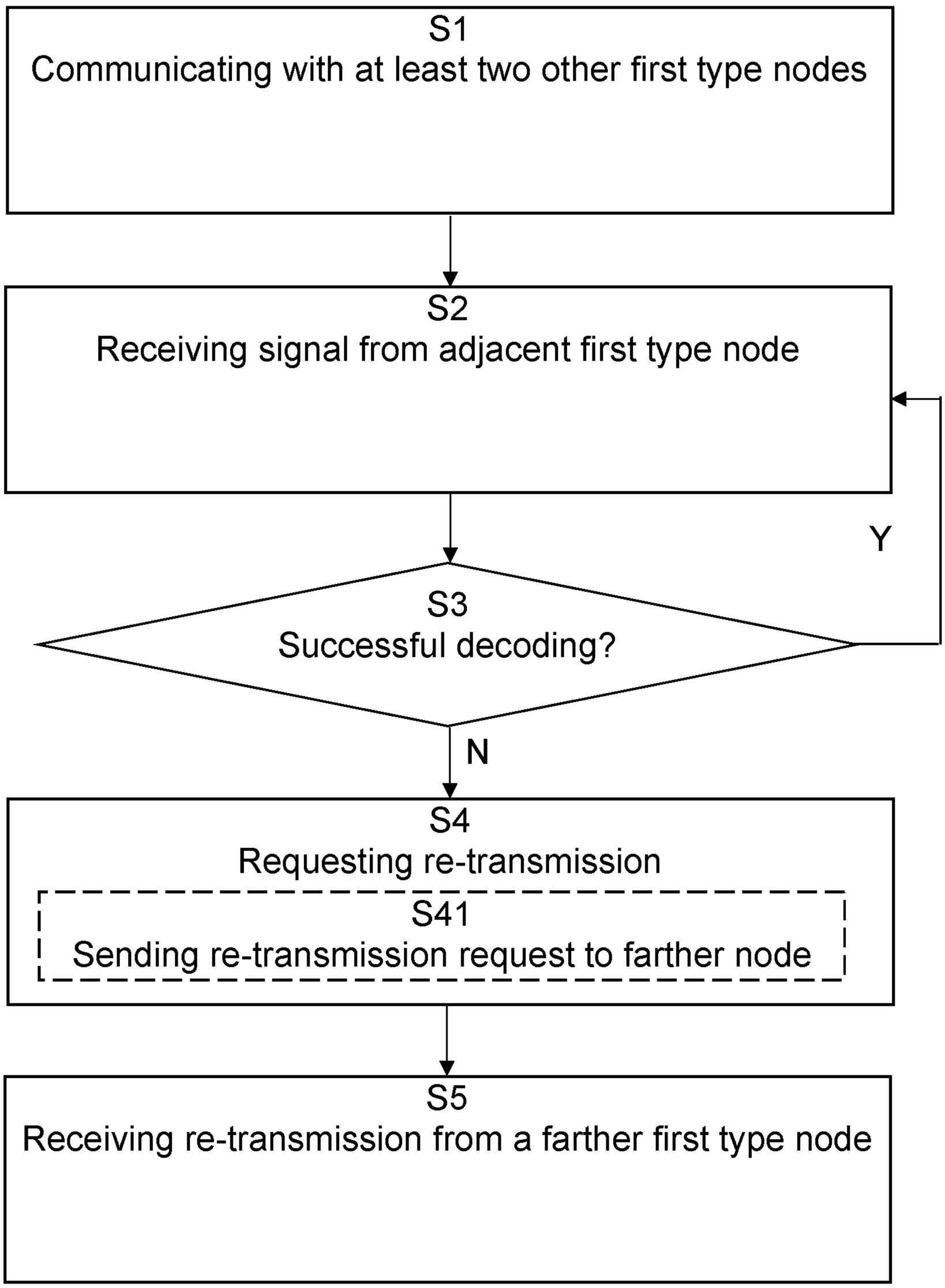

S1
Communicating with at least two other first type nodes
S2
Receiving signal from adjacent first type node
S3
Successful decoding?
Y
N
S4
Requesting re-transmission
S41
Sending re-transmission request to farther node
S5
Receiving re-transmission from a farther first type node

FIG. 7

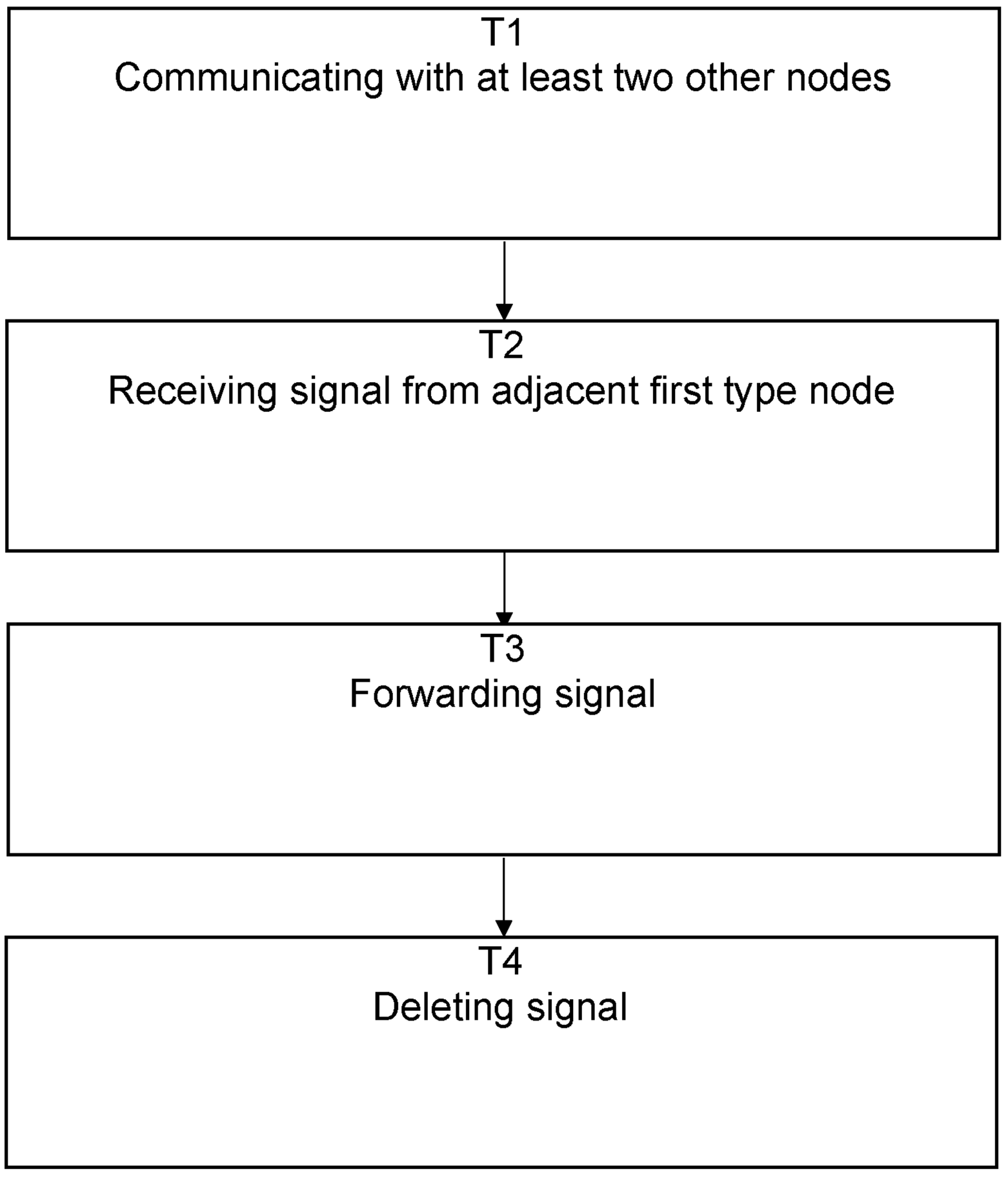

T1
Communicating with at least two other nodes
T2
Receiving signal from adjacent first type node
T3
Forwarding signal
T4
Deleting signal

FIG. 8

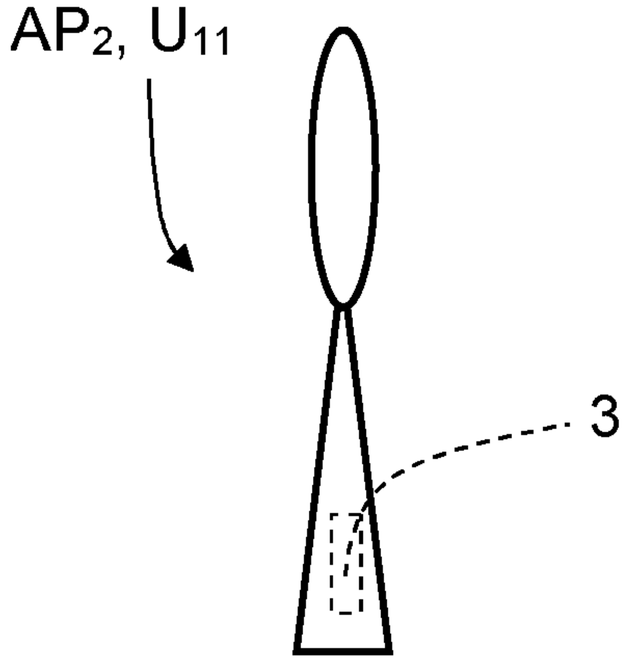


FIG. 9A

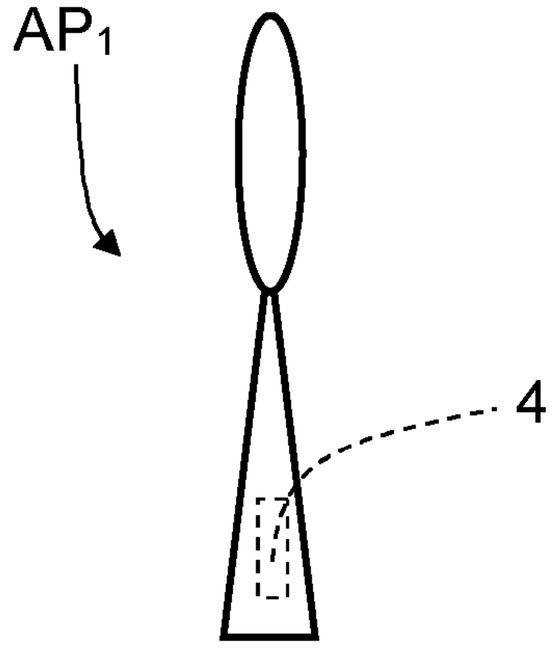


FIG. 9B

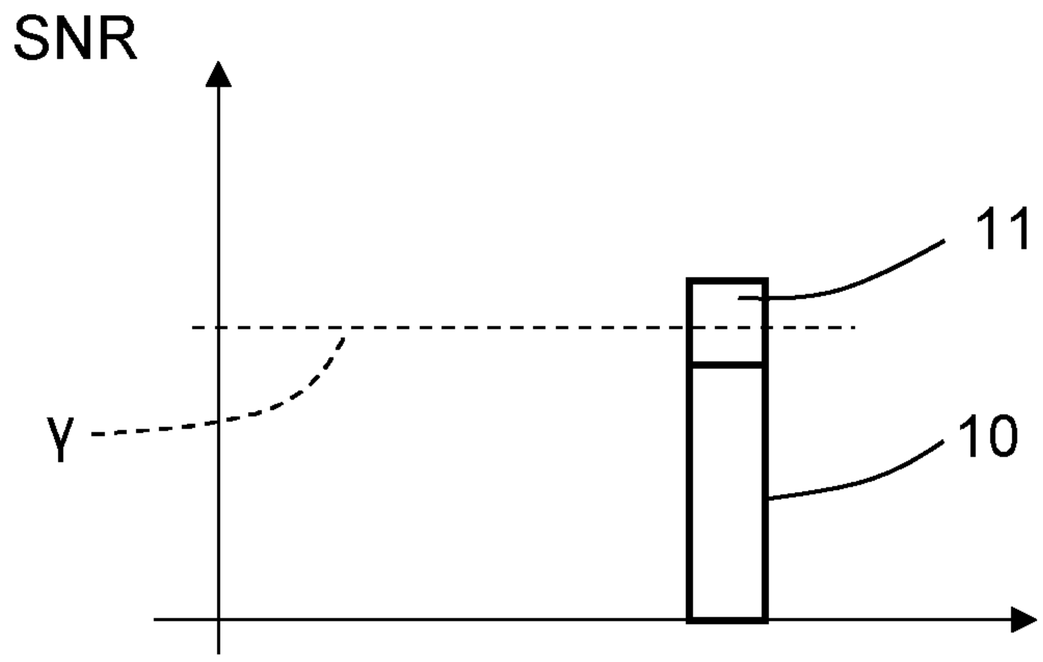


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2019/051117

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: H04B, H04L, H04W

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

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	"Deployment scenarios and use cases for Integrated Access Backhaul", Ericsson, 2018-01-26, R2-180121, 3GPP TSG-RAN WG2, RAN meeting #75, https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_AHs/2018_01_NR/Docs/R2-1801021.zip; figures 1,5A,6; Sec. 2, 2.1, 2.3	1-8, 11-18, 21
A	--	9-10, 19-20

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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

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"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
06-10-2020	06-10-2020

Name and mailing address of the ISA/SE
Patent- och registreringsverket
Box 5055
S-102 42 STOCKHOLM
Facsimile No. + 46 8 666 02 86

Authorized officer
Emma Thyr
Telephone No. + 46 8 782 28 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2019/051117

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	D2: "End-to-end vs. hop-by-hop RLC ARQ design for L2 relaying in IAB", AT&T, 2018-05-25, R2-1808758, 3GPP TSG-RAN WG2 #102, http://www.3gpp.org/ftp/tsg%5Fran/WG2%5FRL2/TSGR2%5F102/Docs/R2%2D1808758%2Ezip; figure 3; Sec. 3	1-8, 11-18, 21
A	--	9-10, 19-20
A	US 20090264123 A1 (AGASHE PARAG A ET AL), 22 October 2009 (2009-10-22); abstract; figure 3	1-21
	--	
Y	Proposals on IAB architectures, 2018-01-27, R2-1801606, TSG RAN WG2 AH, https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_AHs/2018_01_NR/Docs/R2-1801606.zip; whole document	1-8, 11-18, 21
A	--	9-10, 19-20
Y	"Scenario and architecture for IAB", Intel Corporation, 2018-01-26, 3GPP TSG RAN WG2 Meeting, agenda item: 11.1, R2-1800953, https://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_AHs/2018_01_NR/Docs/R2-1800953.zip; whole document	1-8, 11-18, 21
A	--	9-10, 19-20
A	"Way Forward - IAB Architecture for L2/3 relaying", Qualcomm Inc, KDDI, AT&T, Nokia, Nokia Shanghai Bell, Huawei, Ericsson, Intel, LG Electronics, CMCC, Samsung, 2018-03-02, R3-181502, 3GPP TSG-RAN WG3 Meeting #99, agenda item 24.1; whole document	1-21
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A	WO 2019197663 A1 (SONY CORP ET AL), 17 October 2019 (2019-10-17); whole document	1-21
	--	
E	WO 2020182274 A1 (ERICSSON TELEFON AB L M), 17 September 2020 (2020-09-17); whole document	1-21
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2019/051117

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	WO 2020182268 A1 (ERICSSON TELEFON AB L M), 17 September 2020 (2020-09-17); whole document -- --------	1-8, 11-18, 21

Continuation of: second sheet

International Patent Classification (IPC)

H04B 7/155 (2006.01)
H04L 1/18 (2006.01)
H04W 52/46 (2009.01)
H04W 84/12 (2009.01)
H04B 7/024 (2017.01)
H04B 7/0452 (2017.01)
H04W 88/10 (2009.01)
H04W 92/20 (2009.01)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/SE2019/051117

US	20090264123	A1	22/10/2009	AU	2009239547	A1	29/10/2009
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				CA	2720981	A1	29/10/2009
				CN	102017722	A	13/04/2011
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				EP	2283679	A1	16/02/2011
				JP	5362814	B2	11/12/2013
				JP	2011518529	A	23/06/2011
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				US	8185060	B2	22/05/2012
				WO	2009131898	A1	29/10/2009
WO	2019197663	A1	17/10/2019	NONE			
WO	2020182274	A1	17/09/2020	NONE			
WO	2020182268	A1	17/09/2020	NONE			