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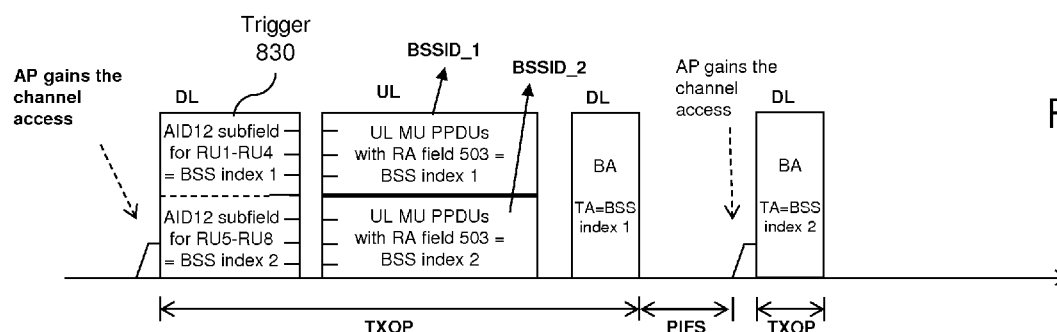


Fig. 8d

(57) Abstract: An AP sends a trigger frame triggering a MU transmission made of RUs. The trigger frame allocates one random resource unit to a specific group of stations by specifying the corresponding BSSID or BSS index in an AID12 subfield associated, within the trigger frame, with the random resource unit. The stations of this group thus contend for access to this specific random RU and can then send, over the random resource unit, a data frame. The first data frame includes a receiver address, RA, subfield set to the BSSID of the first group to allow the AP to efficiently process it. Responsive to receiving the data frame, the AP sends an acknowledgment frame. The latter includes a transmitter address, TA, subfield set to the BSSID of the specific group, thereby allowing the transmitting station to efficiently check whether the data frame has been correctly received.



IMPROVED ACCESS TO RANDOM RESOURCE UNITS BY A PLURALITY OF BSSs5 FIELD OF THE INVENTION

The present invention relates generally to wireless communication networks in which a plurality of groups or basic service sets, BSSs, coexist.

BACKGROUND OF THE INVENTION

10 Wireless communication networks are widely deployed to provide various communication services such as voice, video, packet data, messaging, broadcast, etc. These wireless networks may be multiple-access networks capable of supporting multiple users by sharing the available network resources. Examples of such multiple-access networks include Code Division Multiple Access (CDMA) networks, Time Division Multiple Access (TDMA)
15 networks, Frequency Division Multiple Access (FDMA) networks, Orthogonal FDMA (OFDMA) networks, and Single-Carrier FDMA (SC-FDMA) networks.

In order to address the issue of increasing bandwidth and decreasing latency requirements that are demanded for wireless communications systems in high-density environments, multi-user (MU) schemes are being developed to allow a single access point (AP)
20 to schedule MU transmissions, i.e. multiple simultaneous transmissions to or from non-AP stations or "nodes", in the wireless network. For example, one of such MU schemes has been adopted by the Institute of Electrical and Electronics Engineers (IEEE) in the 802.11ax standard.

Thanks to the MU feature, a station has the opportunity to gain access to the wireless medium via two access schemes: the MU scheme and the conventional Enhanced Distributed
25 Channel Access - EDCA (Single User) scheme.

The 802.11ax standard allows a MU downlink (DL) transmission to be performed by the AP where the latter can perform multiple simultaneous elementary transmissions, over so-called resource units (RUs), to various non-AP stations. As an example, the resource units split a communication channel of the wireless network in the frequency domain, based for instance on
30 Orthogonal Frequency Division Multiple Access (OFDMA) technique.

The 802.11ax standard also allows a MU uplink (UL) transmission to be triggered by the AP, where various non-AP stations can simultaneously transmit to the AP over the resource units forming the MU UL transmission. To control the MU UL transmission by the non-AP stations, the AP sends a control frame, known as a Trigger Frame (TF), by which it allocates resource units
35 to the non-AP stations using 16-bit Association IDentifiers (AIDs) assigned to them upon registration to the AP (so-called scheduled RUs) and/or allocates resource units(known as random RUs) to contention-based access by the non-AP stations.

The above is introduced with respect to a single group of stations that is managed by the access point with which each station has previously registered. In the 802.11 standard,

such a group of stations together with the access point is known as a Basic Service Set (BSS). The access point acts as a master to control the stations within the BSS. The simplest BSS consists of one access point and one station.

Each BSS is uniquely identified by a specific basic service set identifier, BSSID. For
5 a BSS operating in infrastructure mode, the specific BSSID is usually a 48-bit MAC address of the access point. The specific BSSID is the formal name of the BSS and is always associated with only one BSS.

Together with the specific BSSID, each BSS has its own service set identifier, SSID, which is the informal (human) name of the BSS (since this own SSID identifier is often entered
10 into devices manually by a human user).

In a BSS, the stations usually contend for access to the communication medium as described above.

Recent developments provide that a single physical AP can operate as the master stations of a plurality of BSSs, i.e. of a plurality of independent groups of non-AP stations. This
15 avoids using one physical AP per BSS or WLAN. It also makes it possible to use the same primary channel for all BSSs, thereby avoiding channel interference problems.

Such operating scheme where a plurality of BSSs is managed by the same physical AP is performed through so-called virtual access points (virtual APs or VAPs).

A Virtual AP is a logical entity that resides within a physical Access Point (AP). To a
20 client, the VAP appears as an independent access point with its own unique SSID. To implement virtual APs, multiple BSSIDs are used with associated SSIDs. The BSSIDs for the VAPs in the physical AP are usually generated from a base BSSID specific to the underlying physical AP, usually the base MAC address of the AP.

The terms Virtual AP, specific BSSID, BSS and SSID can be used synonymously
25 throughout this document, to designate a group or cell of non-AP stations managed by a physical AP. Depending on the context, specific BSSID and own SSID may further refer to the identifier of a BSS/WLAN, either through a MAC address (specific BSSID) or an informal (human) name (own SSID).

Providing a plurality of SSIDs (or BSS) corresponds to providing various different
30 networks in a particular area. It can give access to different resources and present services which may have differing management or security policies applied. This advantageously allows various categories of user, e.g. staff, students or visitors etc. to be provided with network services which are appropriate to them.

In conventional 802.11 approaches, only one SSID (or BSS) is advertised per
35 signaling message such as a beacon frame. As a consequence, multiple beacons are used to advertise the SSIDs corresponding to the virtual APs configured at the physical AP. This solution is compatible with most 802.11 stations and also allows the SSIDs to support different capability sets.

However, as the number of BSSs increases, more channel utilization results from such signaling. This downside is further increased because the signaling messages are transmitted at low bit rate, usually at the lowest supported data rate so that all clients can receive it.

5 In practice, each VAP sends a beacon frame every 100ms.

To improve this situation of increased channel utilization in case of multiple BSSs, the IEEE 802.11ax standard includes a mechanism to advertise multiple security profiles including BSSID/SSID advertisements, with a single beacon frame.

10 However, the resulting network management is not satisfactory. In particular, the medium access for each BSS (for instance for trigger-based MU UL transmissions) is made independently of the other BSS. As a consequence, as the number of BSSs operating on a given channel increases, so does the amount of contention for data frames.

SUMMARY OF INVENTION

15 It is a broad objective of the present invention to improve this situation, i.e. to overcome some or all of the foregoing limitations. It is thus sought to provide an improved access to resource units in an 802.11 channel in case of multiple wireless networks (BSSs), in particular for MU UL transmissions in 802.11.

20 A wireless communication method in a wireless network according to the invention comprises an access point and a plurality of stations. The access point is capable of managing (or configured to manage) one or more groups of stations, meaning the stations are organized into groups. Each group is uniquely identified by a basic service set identifier, BSSID.

The method comprises the following steps, at the access point:

25 sending a trigger frame triggering a multi-user, MU, transmission made of a plurality of resource units that the stations of one or more groups access to transmit data. The trigger frame allocates one random resource unit to a first group of stations identified by BSSID of the first group in an AID subfield associated, within the trigger frame, with the random resource unit;

30 in response to the trigger frame, receiving, over the random resource unit, a first data frame from one station of the first group. The first data frame includes a receiver address, RA, subfield set to the BSSID of the first group; and

responsive to receiving the first data frame, sending a first acknowledgment frame including a transmitter address, TA, subfield set to the BSSID of the first group.

The method comprises the following steps, at one station belonging to a first group:

receiving the trigger frame;

35 determining one random resource unit allocated to the first group of stations from the BSSID of the first group in an AID subfield associated, within the trigger frame, with the random resource unit;

transmitting the first data frame over the random resource unit; and

in response to the first data frame, receiving the first acknowledgment frame.

Thanks to the invention, stations of various BSSs may transmit data (e.g. uplink to the AP) during the same reserved TxOP. A consequence is that the cost of the signaling (through trigger frames) is reduced, as the contention for the various BSSs is made only once.

This is achieved by the indication of a plurality of groups in the trigger frame used to
5 contend for accessing the network. Indeed, the stations of those groups are thus allowed to access the resource units provided during the reserved transmission opportunity.

Furthermore, using the BSSID of the group to signal the random RUs made available to the stations of this group advantageously does not require modifying the current 802.11ax format of the trigger frames.

10 The use of BSSID in the MAC header of the exchanged data and acknowledgment frames further guarantees an efficient management of communication despite the intermingling of communications from separate BSSs.

A more flexible and more efficient wireless network is thus obtained.

Correlatively, the invention provides an access point in a wireless network also
15 comprising a plurality of stations, the access point being capable of managing one or more groups of stations, each group being uniquely identified by a basic service set identifier, BSSID, the access point comprising at least one microprocessor configured for carrying out the steps defined above.

From station's perspective, the invention also provides a station in a wireless
20 network comprising an access point and a plurality of stations, the access point being capable of managing one or more groups of stations, each group being managed by the access point, the station which belongs to a first one of the groups comprising at least one microprocessor configured for carrying out the steps defined above.

Optional features of embodiments of the invention are defined in the appended
25 claims. Some of these features are explained here below with reference to a method, while they can be transposed into system features dedicated to any AP or station according to embodiments of the invention.

In embodiments, two BSSs may thus be triggered for UL transmission by the same trigger frame. It means, the method further comprises, at the access point and in response to the
30 trigger frame, receiving, over another resource unit, a second data frame from one station of a second and separate group, wherein the second data frame includes a receiver address, RA, subfield set to the BSSID of the second group.

In that case an appropriate acknowledgment is performed. For instance, the method further comprising, at the access point and in response to receiving the second data frame,
35 sending a second acknowledgment frame including a transmitter address, TA, subfield set to the BSSID of the second group, the second acknowledgment frame being separate from the first acknowledgment frame. The stations may thus retrieve (or check) the acknowledgment of the data frame they have sent, from specific acknowledgment frames they can easily identify through the TA subfield.

In embodiments, the first acknowledgment frame is a block acknowledgment frame acknowledging reception of data frames over resource units from only stations belonging to the first group.

5 In embodiments, access to the random resource unit is based on contention between only the stations of the first group. This defines random RUs.

In embodiments, the BSSIDs of the groups are derived from a base BSSID, and the AID subfield includes a BSSID index identifying the first group from amongst the groups having a BSSID derived from the base BSSID.

10 For instance, the BSSID index comprises the n least significant bits of the corresponding BSSID, where the access point is configured to manage a maximum of 2^n groups of stations.

Also, the trigger frame may allocate another random resource unit to all the groups identified by a base BSSID in an AID subfield associated, within the trigger frame, with the other random resource unit.

15 In embodiments, each group is managed by a virtual access point implemented in the access point.

In embodiments, two or more random RUs may be allocated to the same BSS: the trigger frame thus allocates another random resource unit to the first group identified by BSSID of the first group in an AID subfield associated, within the trigger frame, with the other random resource unit.

20 In embodiments, other random RUs may be allocated to other BSSs: the trigger frame thus further allocates one or more other random resource units to one or more other and separate groups of stations identified by BSSID of the other and separate groups in the AID subfields associated, within the trigger frame, with the other random resource units.

25 In embodiments, the random RUs so defined coexist with scheduled RUs: the trigger frame thus further allocates one or more scheduled resource units to respective specific stations identified by an application identifier, AID, of these specific stations in the AID subfields associated, within the trigger frame, with the scheduled resource units.

30 Another aspect of the invention relates to a wireless communication system having an access point and at least one station as defined above.

Another aspect of the invention relates to a non-transitory computer-readable medium storing a program which, when executed by a microprocessor or computer system in a device of a communication network, causes the device to perform any method as defined above.

35 The non-transitory computer-readable medium may have features and advantages that are analogous to those set out above and below in relation to the methods and AP or stations.

At least parts of the methods according to the invention may be computer implemented. Accordingly, the present invention may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally

be referred to herein as a "circuit", "module" or "system". Furthermore, the present invention may take the form of a computer program product embodied in any tangible medium of expression having computer usable program code embodied in the medium.

Since the present invention can be implemented in software, the present invention
5 can be embodied as computer readable code for provision to a programmable apparatus on any suitable carrier medium. A tangible carrier medium may comprise a storage medium such as a hard disk drive, a magnetic tape device or a solid state memory device and the like. A transient carrier medium may include a signal such as an electrical signal, an electronic signal, an optical signal, an acoustic signal, a magnetic signal or an electromagnetic signal, e.g. a microwave or
10 RF signal.

BRIEF DESCRIPTION OF THE DRAWINGS

Further advantages of the present invention will become apparent to those skilled in the art upon examination of the drawings and detailed description. Embodiments of the invention
15 will now be described, by way of example only, and with reference to the following drawings.

Figure 1 illustrates a typical wireless communication system in which embodiments of the invention may be implemented;

Figure 2 illustrates an example of 802.11ax uplink OFDMA transmission scheme, wherein the AP issues a Trigger Frame for reserving a transmission opportunity of OFDMA sub-channels (resource units) on an 80 MHz channel as known in the art;
20

Figure 3 illustrates a format of a Trigger frame;

Figure 4 illustrates how an AP can poll two distinct BSSs using trigger frames;

Figures 5a and 5b illustrates subfields of the Trigger frame of **Figure 3**;

Figure 6 shows a schematic representation a communication device or station in
25 accordance with embodiments of the present invention;

Figure 7 shows a schematic representation of a wireless communication device in accordance with embodiments of the present invention;

Figure 8 illustrate exemplary embodiments of the invention for multiple BSS support with trigger Frame;

Figures 9 illustrate new formats of a Trigger frame, adapted for implementations of the invention; and
30

Figure 10 illustrates, using a flowchart, general steps of a node receiving a Trigger Frame with multiple BSS support, according to embodiments of the invention.

DETAILED DESCRIPTION

35

The invention will now be described by means of specific non-limiting exemplary embodiments and by reference to the figures.

Figure 1 illustrates a communication system in which several communication nodes (or stations) 101–107 exchange data frames over a radio transmission channel 100 of a wireless

local area network (WLAN), under the management of a central station, or access point (AP) 110. The radio transmission channel 100 is defined by an operating frequency band constituted by a single channel or a plurality of channels forming a composite channel.

5 An exemplary wireless network is the 802.11 network according to 802.11ax version 3.0 standard (published in June 2018).

The wireless communication system of **Figure 1** comprises a physical access point 110 configured to manage two or more WLANs (or BSSs), i.e. two or more groups of nodes. Each BSS is uniquely identified by a specific basic service set identifier, BSSID and managed by a virtual AP implemented in the physical AP.

10 In the example shown, the physical AP implements two virtual APs, virtual AP 1 (100A) having MAC address MAC1 as specific BSSID to manage a first WLAN (BSS), and virtual AP 2 (100B) having MAC address MAC2 as specific BSSID to manage a second WLAN (BSS). Of course more WLANs can be implemented, requiring a corresponding number of virtual APs to be implemented in the physical AP.

15 All MAC addresses for the virtual APs are generated based on (or “derive from”) a base MAC address specific to the physical access point, usually the base 48-bit MAC address of AP 110. For instance MAC_i ('i' being a BSS index) used as specific BSSID(i) for virtual AP_i is generated as follows, from the base MAC address BASE_BSSID:

20 $MAC_i = BSSID(i) = (BASE_BSSID \text{ modified to set the } n \text{ LSBs to zero}) \mid ((n \text{ LSBs of } BASE_BSSID) + i) \bmod 2^n$

where LSB refers to the least significant bits, “n” is an AP parameter (integer) defining the maximum number (about 2^n) of possible specific BSSIDs, and ‘|’ operator is an XOR operator. The specific BSSID(i) thus differ one from the other by their n LSBs. The 48-n MSBs of the generated specific BSSIDs are all similar to the corresponding bits of BASE_BSSID.

25 In an implementation, one virtual AP is associated with the BASE_BSSID from which the other BSSIDs (for other virtual APs) are derived.

The BASE_BSSID is also known as “transmitted BSSID”, while the derived BSSIDs are known as “non transmitted BSSID”.

30 As an example, virtual AP 1 provides a WLAN with “guest” as SSID that one or more nodes can join, while virtual AP 2 provides a WLAN with “Employee” as SSID that other nodes can join simultaneously. The security for each WLAN is different, i.e. WEP and WPA. A same device can usually join two WLANs simultaneously if it has two separate WLAN interfaces (e.g. wifi network card). In that case, the device is considered as two nodes in the network, each node being able to join only one WLAN at a time.

35 Some control frames sent by the AP are an important part of 802.11, for instance beacon frames and probe response frames. The nodes are waiting for these frames to know about the WLANs or BSSs available.

These frames let the nodes know that an AP and one or more WLANs are available, but also notify the nodes about important information such as the corresponding SSID or SSIDs,

the corresponding specific BSSID or BSSIDs, the communication mode (Infrastructure or Ad-Hoc), the protection security schemes used (e.g. Open, WEP, WPA-PSK or 802.1X), the support transmission rates used, the channel in operation and optional Information Elements.

When multiple BSSs are provided, multiple beacons are transmitted by the AP, one
 5 for each active BSS, usually each 100 ms. It results in that the nodes have to process beacon frames more frequently and that channel occupation due to control frames is increased (being noted that the control frames such as the beacon frames are transmitted at low rate)..

These drawbacks can be reduced by for example increasing the beacon interval (more than 100 ms) so that the beacon frame of each BSS is sent less frequently. However, this
 10 may cause some nodes not to detect the beacon frame of a given BSS when scanning, and thus to decide a particular BSS (through its SSID) is not available.

To improve this situation, the IEEE 802.11ax standard provides a mechanism to advertise multiple security profiles including BSSID advertisements. Thus, a single Beacon frame is sent rather than multiple Beacon frames in order to advertise a plurality of specific
 15 BSSIDs/SSIDs. In this mechanism, a new Information Element (IE) is defined (Multiple BSSID IE) in the beacon frames sent by one or the other of the multiple virtual APs (i.e. specific BSSIDs).

The transmitter address of such a beacon frame includes the specific BSSID of the transmitting virtual AP, for instance the BASE_BSSID. Furthermore, the Multiple BSSID IE indicates that multiple BSSs is contemplated and provides an indication of the maximum number
 20 N of BSSs managed by the AP, including the BASE_BSSID, to the nodes, as well as the common, inherited information element values of all of the BSSs (e.g. so that all members of the set use a common operating class, channel, channel access functions, etc.) and the unique information elements of each of the other BSSs indexed by their BSSID indexes 'i' (i.e. different advertised capabilities of the various BSSs, including ones from the BSS of the transmitting VAP).

As mentioned above, a BSSID index 'i' is a value between 1 and $N=2^n-1$, which
 25 identifies the BSSID. It may also be noted that the AP may include two or more Multiple BSSID elements containing elements for a given BSSID index in one Beacon frame..

Such a multi BSS beacon frame may also transmit the base address BASE_BSSID to the nodes.

Each non-AP node or station 101-107 registers to the AP 110 or one of the VAPs
 30 during an association procedure. During the well-known association procedure, the AP 110 (or VAP 110A, 110B) assigns a specific Association IDentifier (AID) to the requesting non-AP node. An AID is a 16-bit value uniquely identifying the non-AP station. According to IEEE standard, the value of an AID is assigned in the range 1 to 2007 for Directional multi-gigabit non-AP station; the
 35 5 MSBs of the AID are reserved.

All the stations 101-107, 110 compete one against each other using EDCA (Enhanced Distributed Channel Access) contention, to access the wireless medium in order to be granted a transmission opportunity (TXOP) and then transmit data frames.

To increase wireless network efficiency, multi-user (MU) schemes are available to allow a single station, usually the AP 110, to schedule MU transmissions, i.e. multiple simultaneous transmissions to or from other nodes, in the wireless network. Such a MU scheme has been adopted in 802.11ax, as the Multi-User Uplink and Downlink OFDMA (MU UL and DL OFDMA) procedures.

To actually perform such multi-user transmission, a granted 20MHz channel (200-1 to 200-4) is split into sub-channels 310 (elementary sub-channels), also referred to as sub-carriers or resource units (RUs), that are shared in the frequency domain by multiple users, based for instance on Orthogonal Frequency Division Multiple Access (OFDMA) technique.

This is illustrated with reference to **Figure 2**.

The multi-user feature of OFDMA allows the AP to assign different RUs to different nodes in order to increase competition within a reserved transmission opportunity TXOP. This may help to reduce contention and collisions inside 802.11 networks.

Contrary to downlink OFDMA wherein the AP can directly send multiple data to multiple nodes (supported by specific indications inside the PLCP header), a trigger mechanism has been adopted for the AP to trigger uplink communications from various nodes.

To support an uplink multi-user transmission (during a pre-empted TxOP), the 802.11ax AP has to provide signalling information for both legacy stations (non-802.11ax nodes) to set their NAV and for 802.11ax nodes to determine the Resource Units allocation.

In the following description, the term legacy refers to non-802.11ax nodes, meaning 802.11 nodes of previous technologies that do not support OFDMA communications.

As shown in the example of **Figure 2**, the AP sends a trigger frame (TF) 330 to the targeted 802.11ax nodes to reserve a transmission opportunity. The bandwidth or width of the targeted composite channel for the transmission opportunity is signalled in the TF frame, meaning that the 20, 40, 80 or 160 MHz value is added. The TF frame is a control frame, according the 802.11 legacy non-HT format, and is sent over the primary 20MHz channel and duplicated (replicated) on each other 20MHz channels forming the targeted composite channel. As described above for the duplication of control frames, it is expected that every nearby legacy node (non-HT or 802.11ac nodes) receiving the TF on its primary channel, then sets its NAV to the value specified in the TF frame. This prevents these legacy nodes from accessing the channels of the targeted composite channel during the TXOP.

Based on an AP's decision, the trigger frame TF may define one or more resource units (RUs) 310, or "Random RUs", which can be randomly accessed by the nodes of the network. In other words, Random RUs designated or allocated by the AP in the TF may serve as basis for contention between nodes willing to access the communication medium for sending/uploading data during the reserved transmission opportunity. A collision occurs when two or more nodes attempt to transmit at the same time over the same RU.

The trigger frame TF may also designate one or more Scheduled resource units, in addition or in replacement of the Random RUs. Scheduled RUs may be reserved by the AP for

certain nodes in which case no contention for accessing such RUs is needed for these nodes. Such RUs and their corresponding scheduled nodes are indicated in the trigger frame. For instance, a node identifier, such as the Association ID (AID) assigned to each node upon registration, is added in association with each Scheduled RU in order to explicitly indicate the node that is allowed to use each Scheduled RU.

An AID equal to 0 may be used to identify random RUs.

The multi-user feature of OFDMA allows the AP to assign different RUs to different nodes in order to increase competition. This may help to reduce contention and collisions inside 802.11 networks.

In the example of **Figure 2**, each 20MHz channel (200-1, 200-2, 200-3 or 200-4) is sub-divided in frequency domain into four sub-channels or RUs 310, typically of size 5 Mhz.

Of course the number of RUs splitting a 20MHz channel may be different from four. For instance, between two to nine RUs may be provided (thus each having a size between 10MHz and about 2MHz).

Once the nodes have used the RUs to transmit data to the AP, the AP responds with an acknowledgment frame (not shown in the Figure) to acknowledge the data received. As for the other control frames, the acknowledgment frame is duplicated over each 20MHz channel of such composite channel. Preferably, the acknowledgment frame performs a block acknowledgment, meaning that it acknowledges simultaneously reception of data transmitted over a plurality (e.g. all) of the RUs.

The trigger frame thus defines resource units including a plurality of (random and/or scheduled) resource units that the nodes can access. As currently designed, a trigger frame is specific to a single BSS, meaning that only the nodes belonging to that specific BSS are allowed to access the resource units included in the transmission opportunity reserved by the trigger frame. For instance, the BSSID of the BSS considered (i.e. the MAC address of the virtual AP) is set in the transmitter address field of the header of the trigger frame.

Figure 3 illustrates the MAC format of the trigger frame 330 according to the 802.11ax standard.

The Trigger frame is used to allocate (random and/or scheduled) resource units for UL MU transmission by 802.11ax nodes. The trigger frame is duplicated in each 20MHz of the targeted composite channel to reserve a transmission opportunity over the composite channel. The trigger frame follows the legacy format of control frames (no specific HT preamble).

The TF 330 is made up of a MAC header and of additional fields. The MAC header includes the following fields common to all control frames: a frame control field 501, a duration field 502, a RA (Receiver Address) field 503, a TA (Transmitter Address) field 504. The additional fields, specific to the trigger frame, include a data portion formed of information fields (510 and 520) specific to the TF, and a CRC/FCS (Cyclic Redundancy Check, or Frame Check Sequence, or also called checksum) field. The CRC/FCS field may optionally be preceded by a padding field of variable size, for considerations out of scope of the present invention.

The Duration field 502 is set to the estimated time, in microseconds, required for the pending uplink transmissions, and is used to set the NAV of nodes not targeted by the RA field 503. This Duration field 502 thus sets the expected duration for the solicited transmission opportunity TXOP.

5 The RA field 503 is set to the address of the recipient node or nodes. As a Trigger frame is intended for a group of nodes (a BSS), the standard provides not specifying it to infer broadcasting. As an exemplary implementation, the wildcard MAC address (FF:FF:FF:FF:FF:FF) may be used as a broadcast indication.

10 The TA field 504 is set to the address of the node transmitting the Trigger frame; it is typically the MAC address of the AP which sends the TF. When the AP hosts several virtual APs for multiple BSSs, the MAC address of the current BSS (i.e. the specific BSSID or MAC address of the virtual AP concerned) is used for the TA field 504.

15 As the TF is dedicated to a single BSS, through the specific BSSID set in the TA field 504, the physical AP has to send successively a plurality of trigger frames to provide respective transmission opportunities (with resource units) to various BSSs.

Figure 4 illustrates how the Access Point can poll two distinct BSSs. This can be useful if the AP wants to successively query nodes of distinct BSSs for management matter (like buffer report).

The AP has to send two separate trigger frames for polling two BSSs.

20 The AP gains priority access to the communication medium (at least after a PIFS time period with an idle medium, which is less than the DIFS duration necessary for the nodes managed by the AP to start a new contention procedure), so that it can send a first TF to reserve a first transmission opportunity TXOP 1 for a first BSS, BSS 1. During TXOP 1, the nodes of BSS 1 can access the RUs and upload their data, while the AP acknowledges the reception thereof
25 (ACK/BA in the Figure).

Next, the AP relaxes the communication medium but immediately (after PIFS) obtains priority again for access to the communication medium to send another and second TF to reserve a second transmission opportunity TXOP 2 for a second BSS, BSS 2.

During TXOP 2, the nodes of BSS 2 can access the RUs and upload their data.

30 In the approach of **Figure 4**, the wireless network comprising a physical access point and a plurality of nodes organized into groups, each group being managed by a virtual access point implemented in the physical access point. The nodes contend for an access to the wireless network, and the contention process at each node starts or restarts once the wireless network is detected as idle for a predefined time period (usually DIFS time period after the end of a previous
35 TXOP, for instance after an acknowledgment from the AP or after end of PPDU transmission).

The physical access point thus performs the step of sending a plurality of trigger frames on the wireless network to reserve successive transmission opportunities on at least one communication channel of the wireless network, each transmission opportunity being reserved for a specific group of nodes and including resource units that form the communication channel

and that the nodes of the specific group access to transmit data. Typically, a next trigger frame is sent after a time period (e.g. PIFS) following a previous reserved transmission opportunity, the time period being less than the predefined time period (defining nodes' contention for access to the network, e.g. DIFS).

5 During the time period (PIFS), the network is detected as idle because no node has restarted its contention mechanism and thus no node can access the network in the meantime.

Consequently, the physical access point receives, in response to each trigger frame and during the corresponding reserved transmission opportunity, data from one or more nodes of the group specific to the trigger frame.

10 One advantage of the approach of **Figure 4** is that the nodes perform a conventional processing.

The AP thus performs several TXOP reservations according to the number of BSSs it wants to poll. Each reserved TXOP is independent from one another, in particular because the nodes not addressed by the trigger frame set their NAV to the Duration Field 502, and thus waits
15 for this duration.

The intention of the AP to send successive trigger frames using the above priority (possibility to wait only a single first PIFS duration) may be specified in the trigger frame using a Cascade Indication, so that the nodes not addressed by the first frame can listen to detect the second trigger frame. Nevertheless, this cascading is limited to nodes of a same BSS according
20 to the current specification of the standard.

Figure 5a illustrates Common Info field 510 forming part of the additional fields in the TF 330.

It includes a Cascade Indication subfield 512 to indicate the successive trigger frames. For instance, subfield 512 is set to 0 when a subsequent Trigger frame will follow the current
25 Trigger frame. Otherwise, the Cascade Indication subfield is set to 1.

Common Info field 510 also includes a Trigger Type subfield 515 to indicate the type of the Trigger frame.

The other subfields in Common Info field 510 are of less importance for the present invention (Length, HE-SIG-A Info, CP and LTF Type subfields indicate some parameters to format
30 the HE trigger-based PPDU response, that is to say the uplink multi-user OFDMA frame).

Figure 5b illustrates User Info field 520 also forming part of the additional fields in the TF 330. The User Info field 520 defines the allocation of one or more resource units to nodes of the BSS addressed in TA field 504. A plurality of User Info fields 520 is usually used to define the allocation of all the resource units of the transmission opportunity.

35 User Identifier subfield 521, also known as AID12 subfield 521, contains the 12 LSBs of the Association Identifier (AID) of the node(s) to which the RU identified in RU Allocation field 522 is allocated, to transmit the MPDU(s) in the uplink direction.

The AID is a 16-bit unique value assigned to a node by the AP during association handshake, i.e. during registration. The values other than 1-2007 (0 and 2008-65535) are

reserved, limiting the number of nodes for an AP to 2007. This is why using the 12 LSBs is sufficient. In particular, AID = 0 is reserved for assigning the group of nodes forming the BSS currently addressed (TA Field 504).

The AID management is performed per each virtual AP (i.e. per BSS).

5 RU Allocation subfield 522 indicates the RU or RUs that are allocated to the one or more nodes identified in AID12 subfield 521.

The other fields of User Info field 520 are of less importance for the present invention.

To provide a more efficient usage of the bandwidth in case of multiple BSSs, nodes from various BSSs may be triggered for uplink communication, within a single channel access,
10 i.e. during the same reserved transmission opportunity.

Thanks to the use of a same transmission opportunity, trigger frames can be avoided and/or any new trigger frame during the already reserved transmission opportunity can be sent earlier. Thus occupation of the channel due to the trigger frames is reduced and/or lost waiting time before sending a new trigger frame is also reduced.

15 Various embodiments are proposed below that all relate to a wireless communication method in a wireless network comprising a physical access point and a plurality of nodes/stations organized into groups (BSSs), each group being managed by the physical access point and being uniquely identified by a specific basic service set identifier, BSSID, the method comprising the following steps, at the physical access point:

20 sending a trigger frame on the wireless network to reserve a transmission opportunity on at least one communication channel of the wireless network. The trigger frame triggers a multi-user, MU, transmission made of a plurality of resource units that form the communication channel and that the nodes access to transmit data during the reserved transmission opportunity. The trigger frame identifies a plurality of groups, nodes/stations of which
25 are allowed (only) to access the resources units to transmit data. The trigger frame allocates one random resource unit to a first group of nodes/stations by specifying the BSSID of the first group in the AID12 subfield associated, within the trigger frame, with the random resource unit; and

in response to the trigger frame, receiving, over the random resource units during the reserved transmission opportunity, data (a first data frame) from one node/station of the first
30 group. The data (first data frame) includes a receiver address, RA, subfield set to the BSSID of the first group.

Also, responsive to receiving the first data frame, the AP sends a first acknowledgment frame including a transmitter address, TA, subfield set to the BSSID of the first group

35 Any node belonging to a group, called "first group", and receiving such trigger frame thus determines one random resource unit allocated to the first group of stations from the BSSID of the first group specified in an AID12 subfield associated, within the trigger frame, with the random resource unit. Next, the node can transmit a first data frame over the random resource unit, wherein the first data frame includes a receiver address, RA, subfield set to the BSSID of

the first group. In response to the first data frame, the node receives (from the AP) a first acknowledgment frame including a transmitter address, TA, subfield set to the BSSID of the first group.

Figure 6 schematically illustrates a communication device 600, either a node 101-107 or the access point 110, of the radio network 100, configured to implement at least one embodiment of the present invention. The communication device 600 may preferably be a device such as a micro-computer, a workstation or a light portable device. The communication device 600 comprises a communication bus 613 to which there are preferably connected:

- a central processing unit 611, such as a microprocessor, denoted CPU;
- a read only memory 607, denoted ROM, for storing computer programs for implementing the invention;
- a random access memory 612, denoted RAM, for storing the executable code of methods according to embodiments of the invention as well as the registers adapted to record variables and parameters necessary for implementing methods according to embodiments of the invention; and
- at least one communication interface 602 connected to the radio communication network 100 over which digital data packets or frames or control frames are transmitted, for example a wireless communication network according to the 802.11ax protocol. The frames are written from a FIFO sending memory in RAM 612 to the network interface for transmission or are read from the network interface for reception and writing into a FIFO receiving memory in RAM 612 under the control of a software application running in the CPU 611.

Optionally, the communication device 600 may also include the following components:

- a data storage means 604 such as a hard disk, for storing computer programs for implementing methods according to one or more embodiments of the invention;
- a disk drive 605 for a disk 606, the disk drive being adapted to read data from the disk 606 or to write data onto said disk;
- a screen 609 for displaying decoded data and/or serving as a graphical interface with the user, by means of a keyboard 610 or any other pointing means.

The communication device 600 may be optionally connected to various peripherals, such as for example a digital camera 608, each being connected to an input/output card (not shown) so as to supply data to the communication device 600.

Preferably the communication bus provides communication and interoperability between the various elements included in the communication device 600 or connected to it. The representation of the bus is not limiting and in particular the central processing unit is operable to communicate instructions to any element of the communication device 600 directly or by means of another element of the communication device 600.

The disk 606 may optionally be replaced by any information medium such as for example a compact disk (CD-ROM), rewritable or not, a ZIP disk, a USB key or a memory card

and, in general terms, by an information storage means that can be read by a microcomputer or by a microprocessor, integrated or not into the apparatus, possibly removable and adapted to store one or more programs whose execution enables a method according to the invention to be implemented.

5 The executable code may optionally be stored either in read only memory 607, on the hard disk 604 or on a removable digital medium such as for example a disk 606 as described previously. According to an optional variant, the executable code of the programs can be received by means of the communication network 603, via the interface 602, in order to be stored in one of the storage means of the communication device 600, such as the hard disk 604, before being
10 executed.

 The central processing unit 611 is preferably adapted to control and direct the execution of the instructions or portions of software code of the program or programs according to the invention, which instructions are stored in one of the aforementioned storage means. On powering up, the program or programs that are stored in a non-volatile memory, for example on
15 the hard disk 604 or in the read only memory 607, are transferred into the random access memory 612, which then contains the executable code of the program or programs, as well as registers for storing the variables and parameters necessary for implementing the invention.

 In a preferred embodiment, the apparatus is a programmable apparatus which uses software to implement the invention. However, alternatively, the present invention may be
20 implemented in hardware (for example, in the form of an Application Specific Integrated Circuit or ASIC).

Figure 7 is a block diagram schematically illustrating the architecture of the communication device 600, either the AP 110 or one of nodes 100-107, adapted to carry out, at least partially, the invention. As illustrated, device 600 comprises a physical (PHY) layer block
25 703, a MAC layer block 702, and an application layer block 701.

 The PHY layer block 703 (here an 802.11 standardized PHY layer) has the task of formatting, modulating on or demodulating from any 20MHz channel or the composite channel, and thus sending or receiving frames over the radio medium used 100, such as 802.11 frames, for instance medium access trigger frames TF 430 to reserve a transmission slot, MAC data and
30 management frames based on a 20 MHz width to interact with legacy 802.11 stations, as well as of MAC data frames of OFDMA type having smaller width than 20 MHz legacy (typically 2 or 5 MHz) to/from that radio medium.

 The MAC layer block or controller 702 preferably comprises a MAC 802.11 layer 704 implementing conventional 802.11ax MAC operations, and an additional block 705 for carrying
35 out, at least partially, the invention. The MAC layer block 702 may optionally be implemented in software, which software is loaded into RAM 612 and executed by CPU 611.

 Preferably, the additional block, referred as to multiple BSS management module 705 for controlling access to OFDMA resource units (sub-channels) in case of multiple BSSs,

implements the part of the invention that regards device 600, i.e. transmitting operations for a source node, receiving operations for a receiving node, or operations for the AP.

For instance and not exhaustively, the operations for the AP may include generating and sending trigger frames as defined below, i.e. trigger frames identifying a plurality of groups, instead of a single BSS, to reserve a TXOP for multiple BSSs, and then managing the allocation of resource units during the reserved TXOP to the nodes of the various BSSs; the operations for a node different from the AP may include analyzing received trigger frames to determine if the node is allowed to access some resource units in the context the trigger frames allow several BSSs to communicate during the reserved TXOP.

MAC 802.11 layer 704 and multiple BSS management module 705 interact one with the other in order to provide or process accurately trigger frames according to the invention.

On top of the Figure, application layer block 701 runs an application that generates and receives data packets, for example data packets of a video stream. Application layer block 701 represents all the stack layers above MAC layer according to ISO standardization.

Embodiments of the present invention are now illustrated using various exemplary embodiments in the context of IEEE 802.11ax by considering OFDMA sub-channels. Although the proposed examples use the trigger frame 330 (see **Figure 2**) sent by an AP for a multi-user uplink transmissions, equivalent mechanisms can be used in a centralized or in an adhoc environment (i.e. without an AP). Also the invention is not limited to the 802.11ax context.

Below, the term legacy refers to non-802.11ax nodes, meaning 802.11 nodes of previous technologies that do not support OFDMA communications.

Figures 8 illustrate, through timelines, three embodiments in which the nodes of various BSSs can communicate (upload data to AP) during the same reserved TXOP, contrary to the timeline of **Figure 4**.

The Trigger Frame is modified to identify a plurality of groups of nodes allowed to perform uplink OFDMA transmission in RUs.

In order that the Trigger Frame is received by all the nodes belonging to a plurality of BSS cells, embodiments provides that the sent trigger frame includes a base BSSID, BASE_BSSID, (or transmitted BSSID) which is computed from (or similar to) the base 48-bit MAC address of the physical AP, thus identifying the plurality of groups managed by the physical access point. The base BSSID is seen as an AP address commonly known by all nodes managed by the physical AP. The base BSSID may be specified in the TA or RA field 503 or 504 in a header of the trigger frame. The base BSSID is thus seen as a multi-BSS address.

As all the nodes know the base BSSID (which can be transmitted in or retrieved from the beacon frames), they are able to identify it in TA or RA field. Upon detecting the base BSSID, the nodes know they may be concerned by the reserved TXOP, thus starting to determine in which RU or RUs forming the TXOP they could transmit data (either through contention for random RUs or through direct access for scheduled RU).

The base BSSID may be the base MAC address of the AP, BASE_BSSID, or be the BASE_BSSID modified to set the n LSBs to zero. This is because, given the scheme for generating the specific BSSIDs for the BSSs by the AP, all the specific BSSIDs have the same 48-n MSBs as BASE_BSSID. Thus, the modified BASE_BSSID is sufficient for the nodes to
5 determine whether or not their BSSs are concerned by the trigger frame. This approach clearly voids the n LSBs, so that the nodes can easily detect their corresponding BSSID is concerned, by bit-masking on the other bits (the 48-n MSBs).

In an alternative embodiment, a multi-BSS address to be used to identify the plurality of groups may be a 48-bit MAC address based on BASE_BSSID (either BASE_BSSID itself or
10 the modified BASE_BSSID with the n LSBs set to 0), wherein one bit, for instance bit #0 (usually called the Individual/Group bit), is set to 1 to indicate it is a group address. In this alternative embodiment, only one bit needs to be tested in order to determine whether the BSSID specified in the trigger frame indicates a plurality of BSSs.

These embodiments provide targeting all the BSSs managed by the same physical
15 AP since the base BSSID of the AP is used as "multi-BSS address" to indicate a plurality of BSSs. Of course, other embodiments may be used that identify a subset of all the AP-managed BSSs available. For instance, the TA or RA field used to define the plurality of BSSs may be used as a 48-bit bitmap which associates each of its bits to a given BSS (in increasing order for instance). It is contemplated that 48 BSSs simultaneously managed by a single AP covers a large number
20 of situations. Thus each bit set to 1 in the 48-bit bitmap indicates that the associated BSS is concerned by the TF.

In another alternative embodiment, a multi-BSS address to be used to identify the plurality of groups may be any 48-bit MAC address of one VAP (i.e. any specific BSSID), and the trigger frame format contains an explicit information field for a multiple BSS indication (e.g. as
25 further described by field 913 of **Figure 9a**). In this embodiment, the trigger frame includes at least one multi-BSS field, the multi-BSS field indicating whether the transmission opportunity provides resources units accessible by nodes of a plurality of groups to transmit data, or not; and each group being uniquely identified by a specific basic service set identifier, BSSID, derived from a base BSSID specific to the physical access point, the sent trigger frame includes a specific
30 BSSID of a virtual access point sending the trigger frame.

Figures 8a and **8b** illustrate respectively first and second embodiments in which a plurality of time slots is cascaded within the TXOP reserved by a first trigger frame. To be more precise, the trigger frame includes a cascading field to indicate the reserved transmission opportunity is split into a plurality of successive time slots, each time slot providing resource units
35 that the nodes access to transmit data. It may be the Cascade Indication subfield 512 defined above. Thanks to this subfield, any node receiving the trigger frame and concerned by the reserved TXOP is able to determine that successive time slots are provided during the TXOP.

Figure 8a illustrates the first embodiments in which conventional trigger frames are used, except for the use of a multi-BSS address (such as BASE_BSSID) in TA or RA field 503 or

504. It means that a series of TF 330 is used in cascade in order to grant successively uplink communications for each of the desired BSSs, within the TXOP reserved by the very first TF.

In these first embodiments, the physical access point sends a trigger frame before each time slot to announce the time slot with associated resource units to the nodes. As each
 5 time slot (and thus trigger frame) is dedicated to a single BSS, each trigger frame sent by the AP includes, in addition to the base BSSID to define the plurality of BSSs concerned by the trigger frame, one specific BSSID corresponding to a group of nodes to which the following time slot and associated resource units are reserved. It means that the nodes have to identify the time slot (and thus trigger frame) dedicated to their BSS. To do so, they determine whether one of the trigger
 10 frames received during the reserved transmission opportunity includes, in addition to the base BSSID, a specific BSSID corresponding to their own group, or not;

and in case of positive determining, they access at least one resource unit of the time slot following the determined trigger frame and transmit data over the accessed resource unit to the physical access point.

15 In an exemplary timeline with two BSSs as shown in **Figure 8a**, TF 330-A is used for a first BSS, BSS_1, whereas TF 330-B deals with a second BSS, BSS_2.

After contention or PIFS period elapsed on the medium, the AP sends a first trigger frame 330-A reserving TXOP. To address a plurality of BSSs, the AP indicates BASE_BSSID (or equivalent multi-BSS address that encompasses a plurality of BSSs) in TF 330-A. This indicates
 20 to all the nodes that nodes of two or more BSSs will have an opportunity (through RUs) to transmit during TXOP.

The concerned nodes thus do not set their NAV. For the other nodes (other BSSs), the duration in Duration field 502 of the TF is set to an approximate value covering all the duration of the TXOP (the later TF 330-B will decrease and more finely tune the remaining duration).

25 In one embodiment, TA field 504 is set to identify the plurality of BSSs concerned by the TXOP, either a list of BSSIDs or BASE_BSSID as mentioned above. RA field 503 is set to a specific BSSID value corresponding to a single BSS that is allowed to communicate during the time slot 310-A following TF 330-A. In the example of **Figure 8a**, RA field 503 includes BSSID_1 in order to inform the nodes of BSS 1 that they will have opportunities (RUs) to upload data during
 30 following timeslot 310-A.

In an alternative embodiment, the opposite scheme is implemented, wherein BASE_BSSID or the like to identify a plurality of BSSs is set in RA field 503 field to inform of the multiple BSS support, while a specific BSSID is set in TA 504 to inform that the following time slot is allocated to the corresponding BSS.

35 TF 330-A has its Cascade Indication subfield 512 set to 1 to indicate a plurality of TFs (including itself) is expected. Since BASE_BSSID is indicated in the frame header, the plurality of TFs, and corresponding transmission time slots, will be provided during the same TXOP reserved by the first TF.

If Cascade Indication subfield 512 is not set, meaning the reserved TXOP includes only one BSS, there is no multiple BSS scheme. The nodes not concerned by the unique TF 330 as indicated through the specific BSSID specified in TA or RA field may defer and set its NAV to the Duration Field 502.

5 The nodes of BSS 1 can thus transmit data during time slot 310-A when they access the resource units, either through scheduled RUs or random RUs (as specified in the User Info fields 520). The AP may acknowledge (ACK/BA) the received data.

 Note that the time length of timeslot 310-A may be defined in "HE-SIG-A Info" field 513. This is because 802.11ax standard mandates the AP to set the value of the timeslot in this field 513. This field, that conventionally defines the time duration for the whole TXOP, is now used
10 for a subpart of the TXOP, namely each timeslot per BSS (UL MU PPDU duration per BSS).

 Thanks to this "HE-SIG-A Info" field, the trigger frame may include an indication of a duration of at least one time slot within the reserved transmission opportunity to drive the nodes to end their transmissions during the at least one time slot at the same time.

15 Next, after a SIFS duration (less than the PIFS duration of **Figure 4**) the AP sends another trigger frame 330-B to provide another time slot for a second BSS, BSS 2. TF 330-B thus includes BSSID_2 and BASE_BSSID (or the like) in the TA and RA fields. If Cascade Indication subfield 512 of TF 330-B is not set, meaning TF 330-B defines the last timeslot, there is no longer multiple BSS scheme. The nodes not concerned by the last TF 330 as indicated through the
20 specific BSSID specified in TA or RA field may defer and set its NAV to the Duration Field 502 (through the value of which the AP may refine the duration of TXOP).

 As for the first time slot, the nodes of BSS 2 access the resource units forming 310-B to transmit data.

 This scheme can be iterated any number of times to offer new uplink communication
25 time slots to the various BSSs.

 Once a node has found a TF for its BSS, its corresponding RU to transmit and has transmitted its uplink data over the RU during 310, it may enter in doze mode for each successive remaining TF, or may wait for a new TF specifying again the BSSID of its own BSS during the reserved TXOP.

30 The above shows that, whatever the option selected for the base BSSID and the specific BSSID to be specified in one and the other of transmitter and receiver address fields in a header of the trigger frame, the usage of common BASE_BSSID (or the like) and specific BSSID makes it possible for the nodes to detect multiple BSS support and to locate their assigned TF(s) and transmission time slot(s) (transmission RUs).

35 In a slight variant as introduced above, instead of using the base BSSID, only the specific BSSID may be indicated in the trigger frame (the one of the VAP sending the TF), together with a separate multi-BSS indication (913 discussed below for instance). Bit-masking on the specific BSSID makes it possible for all the nodes to determine whether they are concerned or not by the current reserved TXOP, in case the multi-BSS indication is enabled.

The first embodiments reduce channel occupation duration because only one single medium access is performed and the next TF can be sent using reduced mandatory PIFS interframe space given the priority of the AP due to the reserved TXOP.

Figure 8b illustrates the second embodiments in which a single initial trigger frame
5 is used to define the allocation of resource units in the successive time slots forming the reserved TXOP.

In these second embodiments, the trigger frame includes a list of BSSIDs defining to which groups of nodes the successive time slots and associated resource units are respectively reserved. The list of BSSIDs may be formed of a set of successive information fields in the trigger
10 frame, each field defining a time slot allocation for one or more BSSIDs.

Any node concerned by the received TF (because its BSS is included in the set of BSSIDs indicated in the TF) can thus read the list of BSSIDs from the trigger frame; determine, based on the read list of BSSIDs, one of the time slots that is at least reserved to its own group (a time slot may be reserved for a plurality of groups, using for instance a multi-BSS address, such as REF_BSSID); and access at least one resource unit of the determined time slot and
15 transmit data over the accessed resource unit to the physical access point.

As shown in the exemplary timeline of **Figure 8b**, one single TF 830 is used for directing UL MU transmission of several BSSs successively. To achieve that, TF 830 follows a new format, an example of which is described below with reference to **Figure 9**, in order to provide
20 a list of BSSIDs and inform that a transmission timeslot 310 for each BSSID is allowed to occur in cascading scheme.

Figure 9 illustrates the MAC format of trigger frame 830. The MAC header portion is the same as TF 330 of 802.11ax standard shown in **Figure 3** above. This is to keep compliancy with the MAC protocol. Thus, the BASE_BSSID (or the like to identify a plurality of BSSs) may be
25 used in TA or RA field as explained above to indicate multiple BSS scheme.

In a slight variant, instead of using the base BSSID, only the specific BSSID may be indicated in the trigger frame (the one of the VAP sending the TF), together with a separate multi-BSS indication (913 discussed below for instance). Bit-masking on the specific BSSID makes it possible for all the nodes to determine whether they are concerned or not by the current reserved
30 TXOP, in case the multi-BSS indication is enabled.

In the case of **Figure 8b** (and also **8c** described below), as the trigger frame is general for all the timeslots, the TA and RA fields are used at most only to provide multi-BSS capability. As a result, the TA field 504 may be set to BASE_BSSID (or the like) in order to advertise the nodes that the TXOP follows a multiple BSS scheme. The RA field 503 is the
35 address of the intended recipient nodes: either a wildcard address is used as a broadcast indication, or BASE_BSSID is used again.

The payload of trigger frame 830 is also formed of one Common Info field 910 that may slightly differ from field 510 and a series of Per BSS Info fields 920 which differ from fields 520 to define the allocation of the successive time slots.

As shown in **Figure 9a**, The “Common Info” field 910 has the same format as 510, except that a new bit field, “multi BSS indication” 913, is added to inform, as a double check, of the new format used by the trigger frame. Multi BSS indication 913 is set to 1 (enabled) if the requested TXOP is dedicated to a group of BSSs; and set to 0 otherwise. Thus, the trigger frame includes, in addition to transmitter and receiver address fields, a parameter section including at least one multi-BSS field, the multi-BSS field indicating whether the transmission opportunity provides resources units accessible by nodes of a plurality of groups to transmit data, or not.

However, the same information can be deduced from the use of BASE_BSSID (or the like as defined above) in TA or RA field 503 or 504 of MAC frame header as described above. As a consequence, Common Info field 910 is optional to explicitly declare the multiple BSS scheme, and conventional Common Info field 510 (i.e. without multi-BSS indication 913) may also be used in which case multiple BSS scheme is only declared through the use of a multi-BSS address such as BASE_BSSID in the MAC header.

Of course, in case it is decided the BASE_BSSID or the like to identify the plurality of BSSs is not specified in the MAC frame header, multi-BSS indication bit 913 becomes mandatory in order to detect the multiple BSS format of the TF. Common Info field 910 thus becomes mandatory instead of Common Info field 510.

Detection of multiple BSS scheme is required to distinguish between the format of TF 330 and the format of TF 830.

The above shows that at least two means to allow determining if the next fields follow conventional format 520 or format 920 as now described are provided. As a consequence, by reading the multi-BSS field, a node can determine a structure format of a per-BSS parameter section additional to transmitter and receiver address fields in the received trigger frame.

Figure 9b discloses an exemplary format of Per BSS Info field 920 that gives BSS information for allocating time slots and resource units.

A plurality of per-BSS parameter sections, namely Per BSS Info fields 920, is used in the trigger frame, at least a current one (preferably each one) of the per-BSS parameter sections defining an allocation of resource units to nodes of a specific BSS. The plurality of sections 920 makes it possible to define the allocation of all the time slots forming the reserved TXOP.

BSS identifier field 921 is used to identify a specific BSS (through a specific BSSID). It means the BSSID field identifies one specific group of nodes concerned by the allocation.

BSS identifier field 921 may be a 6-byte address field, in order to receive a full BSSID, which may for instance be the specific BSSID of a specific BSS. In other words, a BSSID in at least one of the BSSID fields is the specific BSSID of one group.

In variants, as the TF has already been successfully filtered by the TA/RA couple through the MAC header (including BASE_BSSID or the like information), it is sufficient to only distinguish between the possible specific BSSIDs generated from BASE_BSSID. Thus a shorter identifier can be used, for instance index (i) identifying the i^{th} BSSID within the multiple specific

BSSIDs derived from the base BSSID (BASE_BSSID), where i is less than $2^n - 1$. The BSSID field is thus n -bit long, where n is the number of bits varying between the specific BSSIDs compared to the base BSSID.

Given the indication provided in each BSS identifier field 921, the plurality of Per BSS Info fields 920 lists a cascade of BSSs and corresponding RU allocation.

TF Index Allocation field 922 is used in coordination with Cascade Indication field 512 to indicate the index of the timeslot concerned by the allocation defined in the current Per BSS Info field 920. In other words, it defines the timeslot the BSS indicated in BSS identifier field 921 will be allowed to use for uplink communication. The timeslots may be indexed with an increasing numbering from the beginning of the reserved TXOP.

Fields 923 to 926 are common parameters of the current BSS, and are equivalent to parameters 523 to 526.

One or more RU Usage fields 927 are then provided.

RU Usage field 927 has the same function as User Info field 520 of **Figure 5b**, namely defining the allocation of the resource units forming the timeslots identified in field 922 to the nodes belonging to the BSS identified in field 921. A plurality of RU Usage fields 927 makes it possible to define the allocation of several RUs, even each RU, forming the timeslots identified in field 922. These fields are thus used to finely tune the RU usage per BSS (or per a given set of BSS if a bitmap is used in 921).

In the example shown in the Figure, two formats 950 and 520 are proposed.

Format 950 is the simplest format and comprises only two fields: User Identifier subfield 521 includes the Association Identifier (AID) of the node (belonging to the BSS identified in field 921) to which the RU or RUs identified in RU Allocation field 522 is/are allocated, to transmit the MPDU(s) in the uplink direction. AID is set to 0 to define random RUs; otherwise it is set to a specific node AID.

Format 520 reuses the entire format of "User Info Field" 520 defined above.

Use of either format may be specified using a dedicated bit before the RU Usage fields 927.

Of course, the trigger frame may mix RU Usage fields 927 conforming to format 920 and others conforming to format 520. In this case, use of either format may be specified using a dedicated bit before each RU Usage field 927.

Any node that wants to know which RU it can access thus has (after having detected a multi-BSS TF) to:

1) read, within the received trigger frame, a plurality of per-BSS parameter sections 920 additional to transmitter and receiver address fields 503, 504;

2) for at least one per-BSS parameter section 920 defining an allocation of resource units to nodes:

determine, based on one BSSID field 921 included in the per-BSS parameter section, whether its own group is concerned by the allocation or not,

in the affirmative of the previous determination, determine, based on one TF Index Allocation field 922 in the per-BSS parameter section, which time slot is concerned by the allocation, the reserved transmission opportunity being either made of one time slot or split into a plurality of time slots, each resource unit being accessed by a single node during a time slot to
5 transmit data, and

determine, based on one or more RU usage fields 927 in the per-BSS parameter section, one or more resource units in the concerned time slot and whether said node is authorized to access the one or more determined resource units.

Next, in case the node is authorized to access the one or more determined resource
10 units, it accesses at least one of the determining resource units during the reserved transmission opportunity and transmits data over the accessed resource unit to the physical access point.

Back to **Figure 8b**, the trigger frame thus has two Per BSS Info fields 920, the first one indicating the first timeslot 310-A (as example "1" in field 922) is allocated to BSS 1 (field 921 set to BSSID_1), while the second one indicates the second timeslot 310-B (as example "2" in
15 field 922) is allocated to BSS 2 (field 921 set to BSSID_2),

Thus the nodes of BSS 1 access the RUs of 310-A according to the RU allocation defined in RU usage fields 927 of the first Per BSS Info field 920, to transmit data to the AP. Once timeslot 310-A for uplink ends, the AP acknowledges reception of the data. As mentioned above, the time length of timeslot 310-A may be defined in "HE-SIG-A Info" field 513. As a plurality of
20 timeslots is provided, the "HE-SIG-A Info" field may be formed to define the successive time duration of each timeslot.

Next, after a SIFS, the second timeslot 310-B starts. It means that an acknowledgment, sent by the physical access point, of data transmitted by nodes in a previous time slot 310-A triggers the start of a next time slot 310-B during the reserved transmission
25 opportunity TXOP. And the next time slot starts after a predefined time period (e.g. a SIFS) after the transmission of the acknowledgment by the physical access point. The acknowledgment ACK/BA of the preceding transmission thus serves as a synchronization point for the next UL MU transmission of a next BSS.

It follows that the nodes of BSS 2 can access the RUs of 310-B according to the RU
30 allocation defined in RU usage fields 927 of the second Per BSS Info field 920 (in the trigger frame), to transmit data to the AP. Once timeslot 310-B for uplink ends, the AP acknowledges reception of the data.

Of course, one understands that a larger number of timeslots can be provided, that follow the mechanism as described above, to provide RUs for successive BSSs.

As readily apparent from **Figure 8b**, channel occupation due to control frames, in particular due to the trigger frames, is substantially reduced compared to the first embodiments. This is because only a single TF is sent that defines the allocation of RUs for a plurality of
35 successive timeslots.

The second embodiments particularly provide high benefits in case of high-loaded cells, i.e. where the total number of available RUs is not enough to fulfil the need of the at least two BSSs.

In these various variants as well as in the conventional approach, the random RUs
 5 signalled using AID=0 are available for the nodes belonging to the current BSS, i.e. the BSS sending the TF in the conventional case or the BSS associated with the current timeslot 310 in the variants of **Figures 8a** and **8b**.

To extend usage of random RUs to the nodes of other BSSs, it is proposed that the trigger frame allocates one random resource unit to a first group of stations by specifying the
 10 BSSID of the first group in an AID12 subfield (subfield 521 – **Figure 5b** or **9b**) associated, within the trigger frame, with the random resource unit. By selecting any BSSID, the AP can provide random RUs to any group of nodes, and not only to its group. It can also mix up, within the same timeslot, various random RUs allocated to various BSSs.

The AP may thus receive over the random resource unit so allocated, a first data
 15 frame from one node of the first group. The first data frame includes a receiver address, RA, subfield set to the BSSID of the first group. This makes it possible for the AP to handle properly the received data frame, in particular by the appropriate VAP.

Due to the above-mentioned mixing up, the AP may also receive over another random resource unit (allocated by the same TF using another BSSID), a second data frame from
 20 one node of a second and separate group. The second data frame includes a receiver address, RA, subfield set to the BSSID of the second group. Consequently, another VAP will handle properly the received second data frame.

To ensure stable wireless network, the AP, for instance the appropriate VAP, then sends, responsive to receiving the first data frame, a first acknowledgment frame including a
 25 transmitter address, TA, subfield set to the BSSID of the first group. In response to receiving the second data frame, the AP (or the appropriate VAP) sends a second acknowledgment frame including a transmitter address, TA, subfield set to the BSSID of the second group, the second acknowledgment frame being separate from the first acknowledgment frame. The data frames exchanged for two BSSIDs are acknowledged then separately.

Figure 9c illustrates the User Info field 520 (**Figure 3**) modified according to this approach. This also applies to any version of RU Usage field 927 (**Figure 9b**).

In this variant, the AID12 subfield 1021 does not contain any station identifier AID since the RU is dedicated for random access. This subfield 1021 is used to carry the BSS identifier (BSSID) of the group of nodes to which the corresponding RU is offered for random access.

The BSSID is thus stored in the AID12 subfield 1021. In order to match the 12 bits
 35 length of subfield 1021, the BSSID is preferably stored using its BSSID index (between 1 to $2^n - 1$) as described earlier. In other words, in this variant, for an AP corresponding to the BASE_BSSID (also named "HE AP", or transmitted BSSID) and supporting the Multi BSS scheme (e.g., with a variable known as dot11MultiBSSIDActivated equal in 802.11ax to true), the AID12

subfield 1021 is equal to a BSSID Index value (between 1 to $2^n - 1$) when the User Info field 520 is addressed (i.e. identifies) to stations that are associated with a BSSID derived from the BASE_BSSID (also named nontransmitted BSSID of the set of multiple derived BSSIDs), that follow the random access procedure and support the multi BSS scheme (i.e. have set the Rx Control Frame To MultiBSS subfield in their HE MAC Capabilities Information field of the HE Capabilities element to 1, according to 802.11ax).

As mentioned above, the nodes are aware of the maximum number N of BSSs managed by the AP, including the BASE_BSSID. Indeed, the AP sends beacon frames to inform the nodes that the N first user identifiers (or AID) ($N = 2^n - 1$) are reserved and correspond to BSS indexes. This knowledge makes it possible for the node to efficiently discriminate the content of subfield 1021, between a station AID and a BSSID index.

Thus, upon receiving a trigger frame implementing this variant, a node can read the User Info fields 520 and determining one random resource unit allocated to its own group (BSS), from the BSSID of the first group specified in an AID12 subfield 521 associated, within the trigger frame, with the random resource unit. In case of positive determining, it can then send a data frame with RA subfield set to the BSSID of the group. An acknowledgment frame with TA subfield set to the BSSID of the group is received thereafter.

For example, if a Multi BSS can contain up to 8 BSSs, the AP reserves 8 identifiers ($8 = 2^3$), and sends beacon frames to inform the nodes that those identifiers (0 and 1-7) are reserved for the BSS indexes. In this example, the AP sends a trigger frame as defined in **Figure 3** that contains (among all others User Info fields 520), three User Info fields 520 as defined in **Figure 9c** to allocate three RUs respectively:

the first one containing for instance a subfield 1021 equal to 2. It indicates that the RU associated with the first User Info field 520 is dedicated to random access for the second BSS (corresponding to the BSS index =2);

the second one containing a subfield 1021 equal to 3, thereby indicating a random RU for the third BSS (corresponding to the BSS index =3); and

the third one containing a subfield 1021 equal to 4, thereby indicating a random RU for the fourth BSS (corresponding to the BSS index =4).

In this example, the nodes of the second BSS can contend to access the medium on the first random RU, the nodes of the third BSS can contend on the second random RU and the nodes of the fourth BSS can contend to access the medium on the third RU. Thus, in addition to the allocation of a random RU for a first group of nodes, the trigger frame allocates one or more other random resource units to one or more other and separate groups of stations by specifying the BSSID of the other and separate groups in the AID12 subfields associated, within the trigger frame, with the other random resource units.

Of course, any combination of random/scheduled RUs can be envisioned.

For instance, the trigger frame can define two or more random RUs for the same BSS (different from the BSS emitting the trigger frame).

Also (in variant or combination), some RUs may be scheduled RUs for nodes of the BSS emitting the trigger frame (transmitted BSSID) or random RUs for this specific BSS (in which case AID12 subfield 512 is set to 0). For the scheduled RUs, the trigger frame further allocates one or more scheduled resource units to respective specific stations by specifying an application identifier, AID, of these specific stations in the AID12 subfields associated, within the trigger frame, with the scheduled resource units.

Figure 8c illustrates the third embodiments in which a plurality of BSSs shares the simultaneous RUs of the same timeslot. Indeed, the reserved transmission opportunity includes resource units that are accessed simultaneously by the nodes (e.g. through OFDMA).

In these third embodiments, the trigger frame assigns at least a first resource unit and a second simultaneous resource unit to respectively a first group of nodes and a second and distinct group of nodes. It requires for each node concerned by the trigger frame to determine a subset of the simultaneous resources units that is assigned to its own group (BSS to which it belongs), and in case the subset is not empty (it may be made of one or more RUs), to access at least one resource unit of the determined subset and transmit data over the accessed resource unit to the physical access point.

The trigger frame thus needs to define the allocation of simultaneous RUs to the various BSSs. Next the allocation of RUs to nodes within a given BSS can follow the conventional scheme described above.

The format of TF as explained above with reference to **Figures 9, 9a, 9b and 9c** can be used.

The general format of TF as shown in **Figure 9** and the format of Common Info field 910 of **Figure 9a** are the same as above. Note that the Cascade Indication field 512 can be set to 0 in the case a single timeslot is provided, as it is the case in **Figure 8c**.

Regarding the Per BSS Info field 920 of **Figure 9b**, it must be noted that, in the case of **Figure 8c**, a single timeslot is provided. Thus TF Allocation field 922 is optional and can be absent (the rule is that if Cascade Indication field 512 is set to 0, there is no field 922). This is to save some bits and thus channel occupation. Of course, in a variant, TF Allocation field 922 can be kept in any case, and be set to 1 (to designate the sole timeslot) in case of a single timeslot.

Still regarding the Per BSS Info field 920, the third embodiments provide that the same timeslot is shared between various BSSs. Thus, a plurality of Per BSS Info field 920 can be used, each one dedicated to a single BSS (identified in BSS identifier field 921) but for the same timeslot, and defining, through one or more RU Usage fields 927, the allocation to its nodes of RUs reserved for this BSS in the timeslot.

In the third embodiments, an AP managing several virtual-APs can dynamically and finely tune the number of RUs per BSSID to occur in parallel (simultaneously).

As an example, if a BSS encounters a low number of nodes or medium contention (typically a "guest" network having poor utilization), then the AP may decide to allocate a limited number of RUs to this BSS, and provide a higher number of RUs to another and denser BSS.

Sharing the simultaneous RUs of the same TXOP or timeslot between various BSSs thus makes it possible to avoid using specific trigger frames for low-used BSSs, which is very time and bandwidth-consuming compared to the limited need.

As a consequence, the AP may dynamically adjust the number of RUs to each BSS, according to TXOP history. In other words, the number of simultaneous resource units assigned to each group of nodes (BSS) may depend on use statistics of use of resource units by each group in one or more previous transmission opportunities.

Fourth embodiments not shown in the Figures combine the second and third embodiments. It means that with a single trigger frame, a plurality of successive timeslots is defined, one or more of the timeslots providing simultaneous RUs assigned to nodes of different BSSs. Preferably, all the timeslots are shared between BSSs.

The Cascade Information field 512 is thus set to 1.

Fifth embodiments may apply to any of the second to fourth embodiments.

The fifth embodiments consist in letting some RUs or timeslots opened to access to a plurality of BSSs. In other words, there is no specific allocation provided to RUs. A consequence is that a pure random access by two or more (preferably all the BSSs managed by the AP) is achieved.

This approach can be considered as an overall broadcast BSS, in order to collect the overall needs (node management like registration, buffer status, etc.) of the BSSs managed by an AP.

Various degrees of this approach can be achieved.

At RU level, the trigger frame defines at least one resource unit that is accessible by any node from any one of two or more BSSs. Before accessing this resource unit, any node must check whether its own BSS corresponds to one of the two or more BSSs as specified.

At timeslot level, the trigger frame defines that all the resource units of at least one time slot are accessible by any node from any one of two or more groups, the reserved transmission opportunity being either made of one time slot or split into a plurality of time slots, each resource unit being accessible by a single node during a time slot to transmit data.

At TXOP level, the trigger frame defines that all the resource units in the reserved transmission opportunity are accessible by any node from any one of two or more groups.

The same format of TF as defined above with reference to **Figures 9, 9a, 9b and 9c** can be used.

However, since one or more RUs are assigned to a plurality of BSSs, BSS identifier field 921 can be used to indicate a plurality of BSSs (through a list of BSSIDs or using a multi-BSS address such as BASE_BSSID or using a bitmap). In that case it means the BSSID field identifies a plurality of groups of nodes concerned by the allocation.

In case BSS identifier field 921 is a 6-byte address field, it can directly receive BASE_BSSID or any multi-BSS address that identify a group of BSSIDs or a 48-bit bitmap. In

other words, a value in the BSSID field may be the base BSSID so that all the groups of nodes are concerned by the allocation defined by the current per-BSS parameter section 920.

Instead of setting a BSSID identifying a plurality of groups of nodes, or a corresponding index, BSS identifier field 921 may receive a bitmap as briefly introduced above, each bit in the bitmap being associated with a respective group of nodes (according to an increasing numbering order for instance, like a BSS index). This makes it possible to define any group of BSSs. The BSS associated with each bit of the bitmap is known by all the nodes, including the AP.

For instance, an 8-bit bitmap for 921 supports up to 8 BSSs. Longer bitmaps can be used to adapt to the number of BSSs simultaneously managed by the physical AP.

The use of a bitmap advantageously allows a common configuration for several BSSs to be set in a single "Per BSS Info" field 920.

Any node receiving the trigger frame and belonging to a BSS concerned by the TF will analyze the embedded Per BSS Info fields 920 to determine which field 920 defines a RU allocation for its BSS. To do so, it first reads each bitmap in each Per BSS Info field 920 in order to determine whether the bit associated with its own group is enabled in the bitmap so that its group is concerned by the allocation defined in the current Per BSS Info field 920.

The RU Usage fields 927 defined above can be used, with AID=0 in field 521 to allow any node of the BSSs indicated in BSS identifier field 921 to contend for access to the RUs indicated in field 522.

In the particular case where the RU or timeslot or TXOP is let opened to access to all the BSSs managed by the physical AP, RU Usage field 927 can be empty because all the BSSs use the same parameters.

Figure 10 illustrates, using a flowchart, general steps of a method according to the invention at one node 600 different from the AP.

At step 1000, node 600 receives a Trigger frame from an Access Point.

If the receiving node belongs to a BSS (or virtual BSS) of the transmitting AP, the Trigger Frame is not filtered by the PHY layer as defined in the standard. The filtering is made on so-called "colors" defined in the 802.11ax standard, which mandates that the BSS colors of all the multiple BSSs managed by a single AP are the same.

At step 1001, node 600 analyzes the received trigger frame at the MAC layer (fields in **Figure 3** or **9**). In particular, TA and RA fields 503, 504 are analyzed.

It checks whether the received TF defines a multiple BSS scheme, from which it is registered with.

It consists in checking whether one of TA or RA defines a plurality of BSSs, e.g. a set of BSSIDs, or not, i.e. if it includes BASE_BSSID or any other multi-BSS address (e.g. a bitmap) or a multi-BSS indication 913 that is enabled.

In a variant where random RUs are provided to other BSSs using the User Info field scheme of **Figure 9c**, node 600 may check whether random RUs are provided to other BSSs (i.e. is there any AID12 subfield 521 including a BSS index from 1 to 2^n-1 ?).

If no multiple BSS scheme is used or the multi-BSS address does not encompass
 5 the specific BSSID of node 600 (e.g. does not match BASE_BSSID to which node 600 is registered), conventional process is implemented at step 1010.

Otherwise, step 1002 is performed to determine whether its BSS is concerned by the TXOP or not. This may be based on two items of information:

first, whether or not the BSSID of its own BSS belongs to a set of BSSIDs defined
 10 by the multiple BSS scheme of the trigger frame (e.g. is its own BSS index set in one of the AID12 subfield 521?); and

optionnaly second, if the Cascade Indication field 512 is set to 1 (a plurality of timeslots is provided), whether or not the BSSID of its own BSS is indicated in at least one BSS Identifier field 921 (in which case a timeslot is allocated to its own BSS, if the format of **Figure 9b**
 15 is used).

In case of negative determination (output "no" at test 1003), algorithm ends and the node delays for the time duration specified in Duration Field 502.

Otherwise, step 1004 is executed to determine the RU or RUs the node can access, either through contention (random access RU) or because the RU is scheduled to it.

In the first embodiments, the Cascade Indication field 512 is set to 1 and node 600
 20 waits for a trigger frame having a RA specifying the specific BSSID of the BSS to which node 600 belongs. It may be the first TF or any successive TF within the reserved and granted TXOP. Upon detecting a TF dedicated to its own BSS, the User Info fields 520 make it possible for node 600 to know exactly the RU or RUs it can access (if AID=0 in field 521, the RU identified in field 522
 25 can be accessed through contention, while if field 521 stores the AID of node 600, the RU identified in field 522 can be accessed directly without contention).

In the second to fifth embodiments, the Per BSS Info field 920 of the received trigger frame is deeply analyzed by node 600 to determine the RU or RUs it can access.

It first requires finding the one or more Per BSS Info fields 920 that its own BSS is
 30 concerned with. This is achieved by analyzing BSS Identifier field 921 which should either set the specific BSSID of the BSS of node 600 or a multi-BSS address (including a broadcast address) that encompasses the specific BSSID of its own BSS.

Once such Per BSS Info fields 920 have been found, the corresponding timeslots are determined using TF index Allocation field 922. Node 600 thus now knows the timeslots its
 35 own BSS is concerned with.

Next, for each of these timeslots, node 600 determines to which RU or RUs it is eligible for access. This includes the random RUs and the scheduled RUs. This determining is made by analyzing the RU Usage fields 927 defined in the found Per BSS Info fields 920. The RU or RUs identified in field 522 for which AID12 subfield 521 is the AID of node 600 are

scheduled RU or RUs allocated to this node only. On the other hand, the RU or RUs identified in field 522 for which AID12 subfield 521 is AID=0 are random RU or RUs to which node 600 can access through contention.

In simpler embodiments where AID12 subfields 521 are set to BSS indexes to defined random RUs for various BSSs, node 600 may merely detect one or more subfields 512 (Figure 9c) set to the BSS index of its own group (BSS) to infer random RU or RUs it can access (using contention).

By using TF format described in Figure 9c, the AP can allow node 600, in specified BSSID, to access a RU through contention without Per BSS Info fields 920 in the TF. That is using TF format described in Figure 9c can make size of the TF smaller than using TF format described in Figure 9.

As a consequence, node 600 knows the RU or RUs it can access.

In embodiments, RU allocation by the AP may provide only one RU to a given node. In that case, once an RU node 600 can access has been identified, the analysis of the RU Usage fields 927 ends.

Next to step 1004, step 1005 is performed during which node 600 accesses one (or more) of the RUs determined at step 1004 and transmits its trigger-based PPDU in uplink direction to the AP. As mentioned above, the UL PPDU shall end at the time indicated in the "HE-SIG-A Info" field 513 of the Trigger frame that solicited the TXOP.

In the first, second, fourth and fifth embodiments, it may require for the node to wait for the appropriate timeslot, as specified in field 922.

Preferably, node 600 uses its own specific BSSID in RA field of MAC header of UL frame (instead of BASE_BSSID as mentioned in the trigger frame). This indication helps the AP to classify the received UL frames per BSS (note also that a node is definitively identified by its AID along with the BSSID context).

Figure 8d illustrates a scenario where a plurality of RUs (here RU1-RU4) are made available for contention (i.e. random RUs) to nodes of a first BSS (BSS index = 1 in corresponding AID12 subfield 521 of TF 830) and another plurality of RUs (here RU5-RU8) are made available for contention (i.e. random RUs) to nodes of a second BSS (BSS index = 2 in corresponding AID12 subfield 521). The same applies when a single random RU is provided for a BSS and/or when random RUs are provided for a higher number of BSSs.

Nodes of the first BSS thus use RU1-RU4 to send UL PPDU with RA field 530 set to their own BSS index, i.e. BSS index = 1. Simultaneously, nodes of the second BSS use RU5-RU8 to send UL PPDU with RA field 530 set to their own BSS index, i.e. BSS index = 2. The AP receiving those UL PPDU handles them appropriately, i.e. using respective VAPs.

The AP (or corresponding VAP) then acknowledges reception of the UL PPDU. The acknowledgment frame is sent over the whole 20 MHz channel (including all RUs). In the example shown, the UL PPDU received for a first BSS (here BSS index 1) are block-acknowledged during the triggered TXOP. The acknowledgment frame is a Multi-STA BlockAck frame and includes its

TA field set to BSS index 1, for the nodes of this BSS to be able to efficiently check whether their sent UL PPDU have been correctly received by the AP.

The UL PPDU of the other BSSs (here only another one) are acknowledged when the AP gains another (EDCA) access to the channel, i.e. during another TXOP granted to the AP.

5 In the example shown, the UL PPDU received for the second BSS (here BSS index 2) are block-acknowledged during a subsequent TXOP. The acknowledgment frame includes its TA field set to BSS index 2, for the nodes of this BSS to be able to efficiently check whether their sent UL PPDU have been correctly received by the AP.

10 As an optional embodiment, those acknowledgment frames (that is to say the acknowledgment frames for BSS index 1 and 2 according to the example of **Figure 8d**) are both transmitted in a broadcast RU of a HE DL MU PPDU frame. In that case, the transmitted BSSID AP collects the acknowledgments for the various BSSIDs derived from BASE_BSSID (also known as co-located BSSIDs of the multiple BSSID set), and aggregates them in this unique RU dedicated to the whole set.

15 In an alternative, each acknowledgment frame for a given BSS index is conveyed in a dedicated RU of the HE DL MU PPDU frame, wherein the RU identifies the BSS index (AID value of the DL RU matches the BSS index of which the acknowledgment frame pertains).

The TA and RA fields of each single-STA BA (block acknowledgment) frame are set the BSSID of the corresponding BSS.

20 In the example of **Figure 8d**, the random RUs defined through the use of BSS indexes may be combined with conventional random RUs (AID12=0 available only for the nodes of the BSS transmitting the TF) and/or conventional scheduled RUs (AID12 identifies, using an AID, a node of the BSS transmitting the TF).

25 Although the present invention has been described hereinabove with reference to specific embodiments, the present invention is not limited to the specific embodiments, and modifications will be apparent to a skilled person in the art which lie within the scope of the present invention.

30 Many further modifications and variations will suggest themselves to those versed in the art upon making reference to the foregoing illustrative embodiments, which are given by way of example only and which are not intended to limit the scope of the invention, that being determined solely by the appended claims. In particular the different features from different embodiments may be interchanged, where appropriate.

35 In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. The mere fact that different features are recited in mutually different dependent claims does not indicate that a combination of these features cannot be advantageously used.

CLAIMS

1. A wireless communication method in a wireless network comprising an access point and a plurality of stations, the access point being capable of managing one or more groups of stations, each group being uniquely identified by a basic service set identifier, BSSID, the method comprising the following steps, at the access point:

5 sending a trigger frame triggering a multi-user, MU, transmission made of a plurality of resource units that the stations of one or more groups access to transmit data, wherein the trigger frame allocates one random resource unit to a first group of stations identified by BSSID of the first group in an AID subfield associated, within the trigger frame, with the random resource unit;

10 in response to the trigger frame, receiving, over the random resource unit, a first data frame from one station of the first group, wherein the first data frame includes a receiver address, RA, subfield set to the BSSID of the first group; and

15 responsive to receiving the first data frame, sending a first acknowledgment frame including a transmitter address, TA, subfield set to the BSSID of the first group.

2. The method of Claim 1, further comprising, at the access point and in response to the trigger frame, receiving, over another resource unit, a second data frame from one station of a second and separate group, wherein the second data frame includes a receiver address, RA, subfield set to the BSSID of the second group.

3. The method of Claim 2, further comprising, at the access point and in response to receiving the second data frame, sending a second acknowledgment frame including a transmitter address, TA, subfield set to the BSSID of the second group, the second acknowledgment frame being separate from the first acknowledgment frame.

25 4. A wireless communication method in a wireless network comprising an access point and a plurality of stations, the access point being capable of managing one or more groups of stations, each group being uniquely identified by a basic service set identifier, BSSID, the method comprising the following steps, at one station belonging to a first group of stations:

30 receiving a trigger frame triggering a multi-user, MU, transmission made of a plurality of resource units that the stations of one or more groups access to transmit data, wherein the trigger frame allocates one random resource unit to the first group of stations identified by BSSID of the first group in an AID subfield associated, within the trigger frame, with the random resource unit;

35 determining one random resource unit allocated to the first group of stations from the BSSID of the first group in an AID subfield associated, within the trigger frame, with the random resource unit;

transmitting a first data frame over the random resource unit, wherein the first data frame includes a receiver address, RA, subfield set to the BSSID of the first group; and

in response to the first data frame, receiving a first acknowledgment frame including a transmitter address, TA, subfield set to the BSSID of the first group.

5 **5.** The method of Claim 1 or 4, wherein the first acknowledgment frame is a block acknowledgment frame acknowledging reception of data frames over resource units from only stations belonging to the first group.

6. The method of Claim 1 or 4, wherein access to the random resource unit is based on contention between only the stations of the first group.

10 **7.** The method of Claim 1 or 4, wherein the BSSIDs of the groups are derived from a base BSSID, and the AID subfield includes a BSSID index identifying the first group from amongst the groups having a BSSID derived from the base BSSID.

8. The method of Claim 7, wherein the BSSID index comprises the n least significant bits of the corresponding BSSID, where the access point is configured to manage a
15 maximum of 2^n groups of stations.

9. The method of Claim 7, wherein the trigger frame allocates another random resource unit to all the groups identified by a base BSSID in an AID subfield associated, within the trigger frame, with the other random resource unit.

10. The method of Claim 1 or 4, wherein each group is managed by a virtual
20 access point implemented in the access point.

11. The method of Claim 1 or 4, wherein the trigger frame allocates another random resource unit to the first group identified by BSSID of the first group in an AID subfield associated, within the trigger frame, with the other random resource unit.

12. The method of Claim 1 or 4, wherein the trigger frame further allocates one or
25 more other random resource units to one or more other and separate groups of stations identified by BSSID of the other and separate groups in the AID subfields associated, within the trigger frame, with the other random resource units.

13. The method of Claim 1 or 4, wherein the trigger frame further allocates one or more scheduled resource units to respective specific stations identified by an application
30 identifier, AID, of these specific stations in the AID subfields associated, within the trigger frame, with the scheduled resource units.

14. A non-transitory computer-readable medium storing a program which, when executed by a microprocessor or computer system in a device of a communication network, causes the device to perform the method of Claim 1 or 4.

15. An access point in a wireless network also comprising a plurality of stations, the access point being capable of managing one or more groups of stations, each group being uniquely identified by a basic service set identifier, BSSID, the access point comprising at least one microprocessor configured for carrying out the steps of:

5 sending a trigger frame triggering a multi-user, MU, transmission made of a plurality of resource units that the stations of one or more groups access to transmit data, wherein the trigger frame allocates one random resource unit to a first group of stations identified by BSSID of the first group in an AID subfield associated, within the trigger frame, with the random resource unit;

10 in response to the trigger frame, receiving, over the random resource unit, a first data frame from one station of the first group, wherein the first data frame includes a receiver address, RA, subfield set to the BSSID of the first group; and

 responsive to receiving the first data frame, sending a first acknowledgment frame including a transmitter address, TA, subfield set to the BSSID of the first group.

15 **16.** A station in a wireless network comprising an access point and a plurality of stations, the access point being capable of managing one or more groups of stations, each group being uniquely identified by a basic service set identifier, BSSID, the station which belongs to a first one of the groups comprising at least one microprocessor configured for carrying out the steps of:

20 receiving a trigger frame triggering a multi-user, MU, transmission made of a plurality of resource units that the stations of one or more groups access to transmit data, wherein the trigger frame allocates one random resource unit to the first group of stations identified by BSSID of the first group in an AID subfield associated, within the trigger frame, with the random resource unit;

25 determining one random resource unit allocated to the first group of stations from the BSSID of the first group in an AID subfield associated, within the trigger frame, with the random resource unit;

 transmitting a first data frame over the random resource unit, wherein the first data frame includes a receiver address, RA, subfield set to the BSSID of the first group; and

30 in response to the first data frame, receiving a first acknowledgment frame including a transmitter address, TA, subfield set to the BSSID of the first group.

17. A wireless communication system having an access point according to Claim 15 and at least one station according to Claim 16.

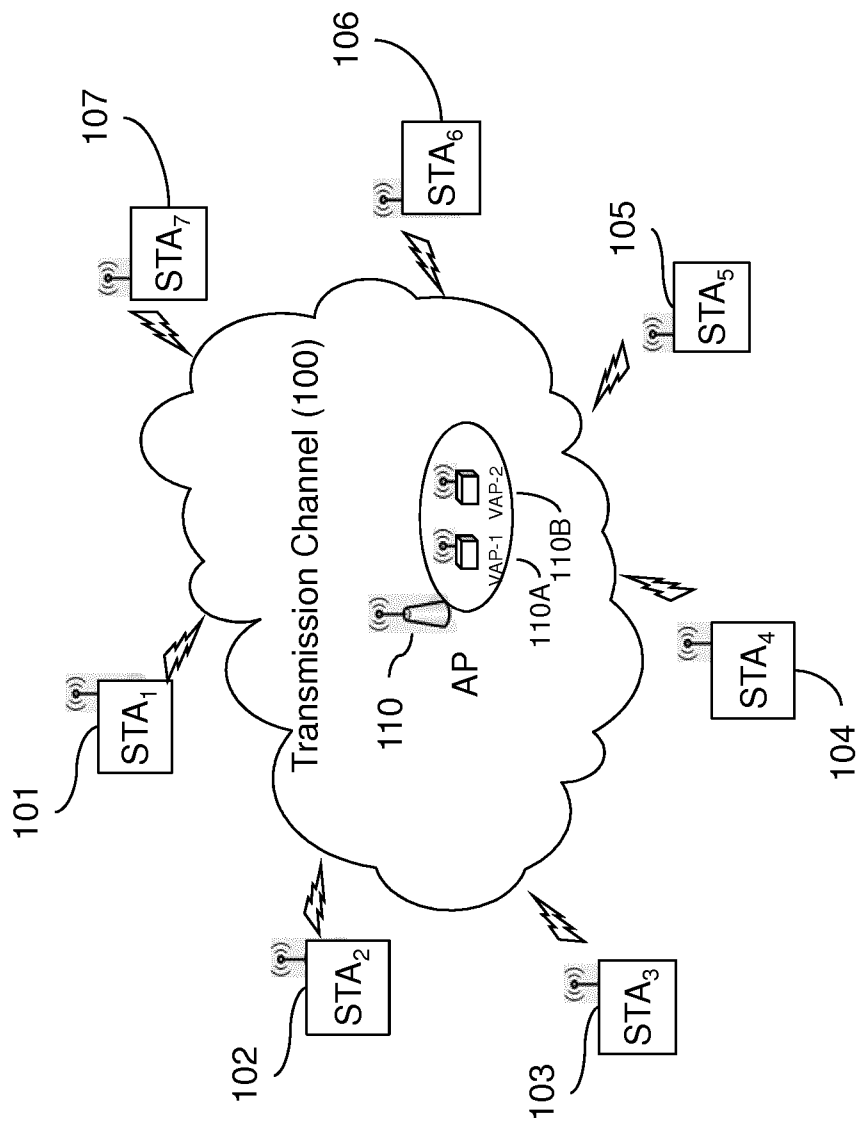


Fig. 1

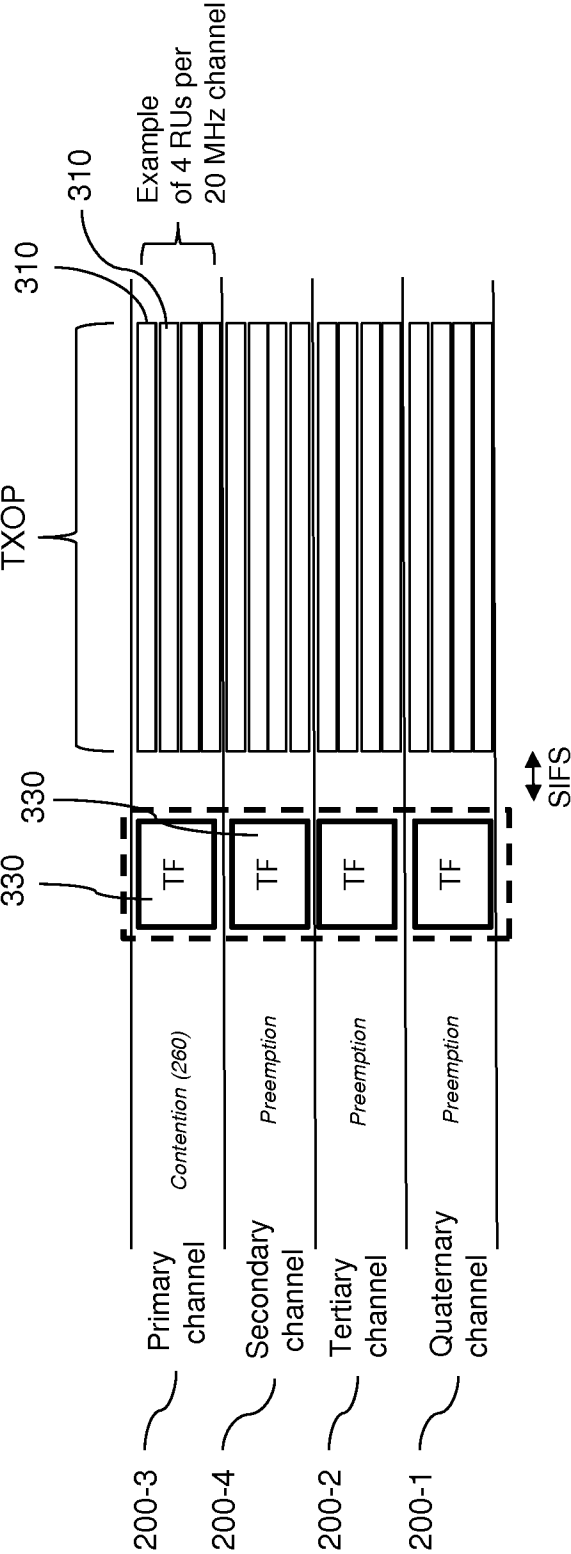


Fig. 2

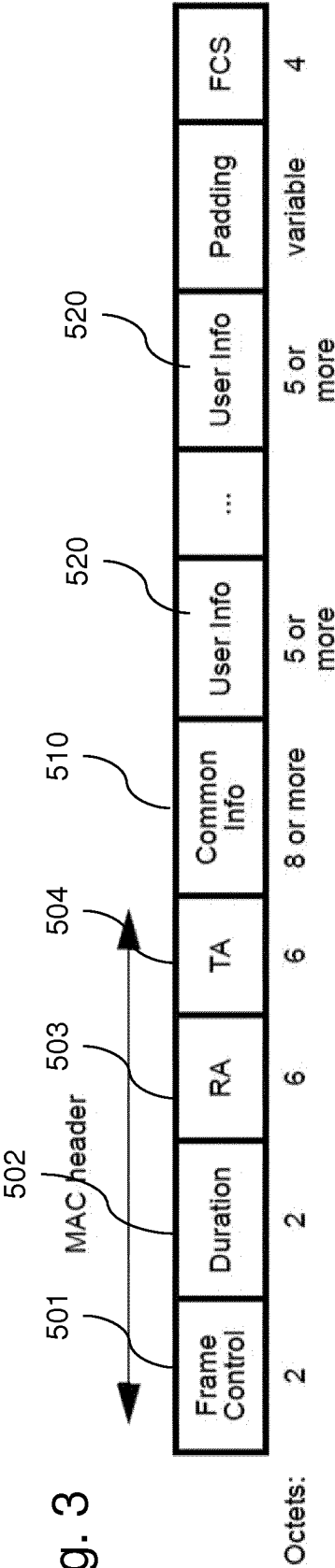


Fig. 3

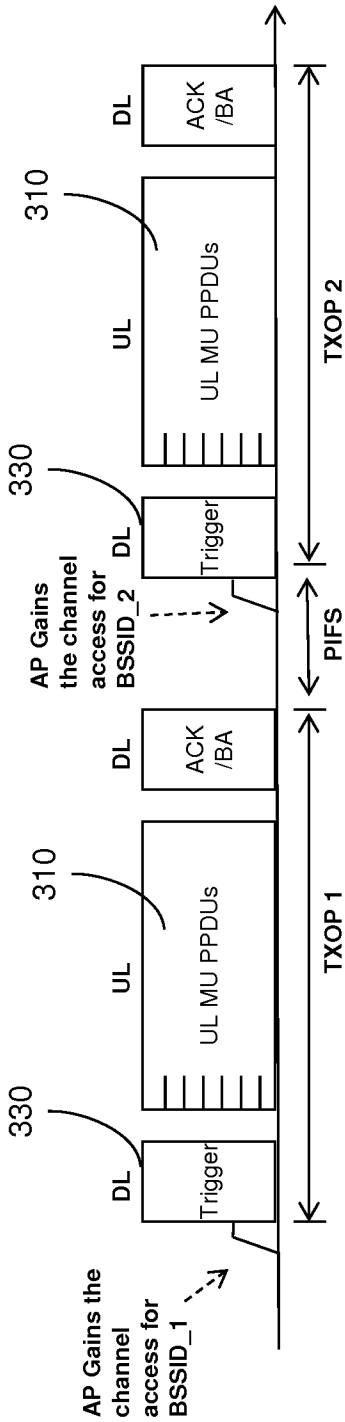


Fig. 4

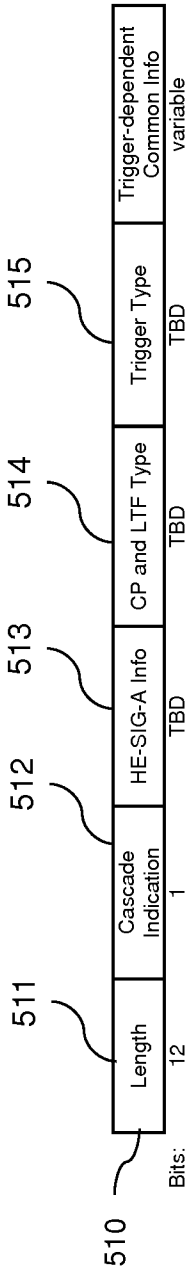


Fig. 5a

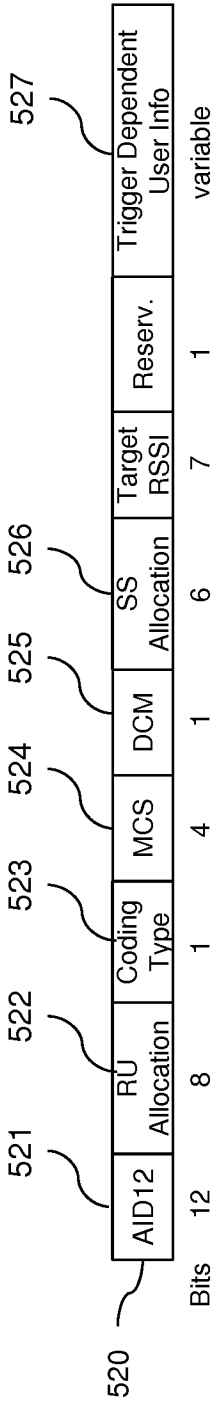


Fig. 5b

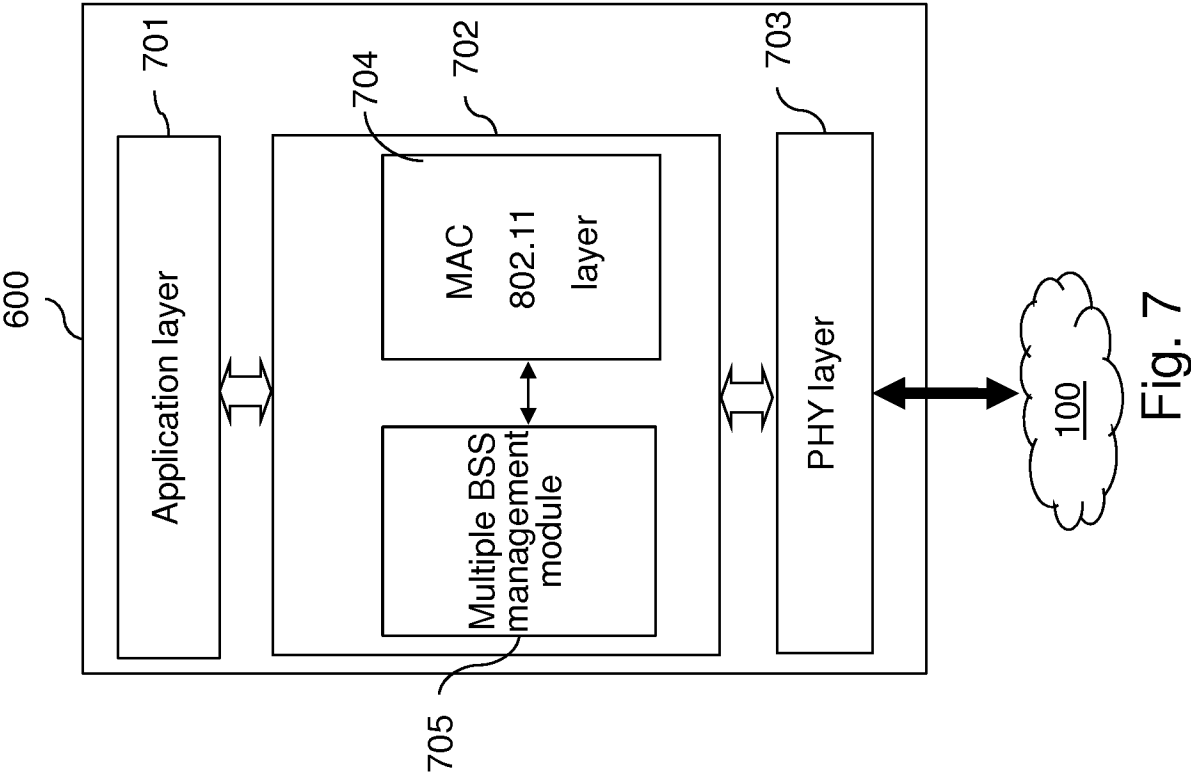


Fig. 7

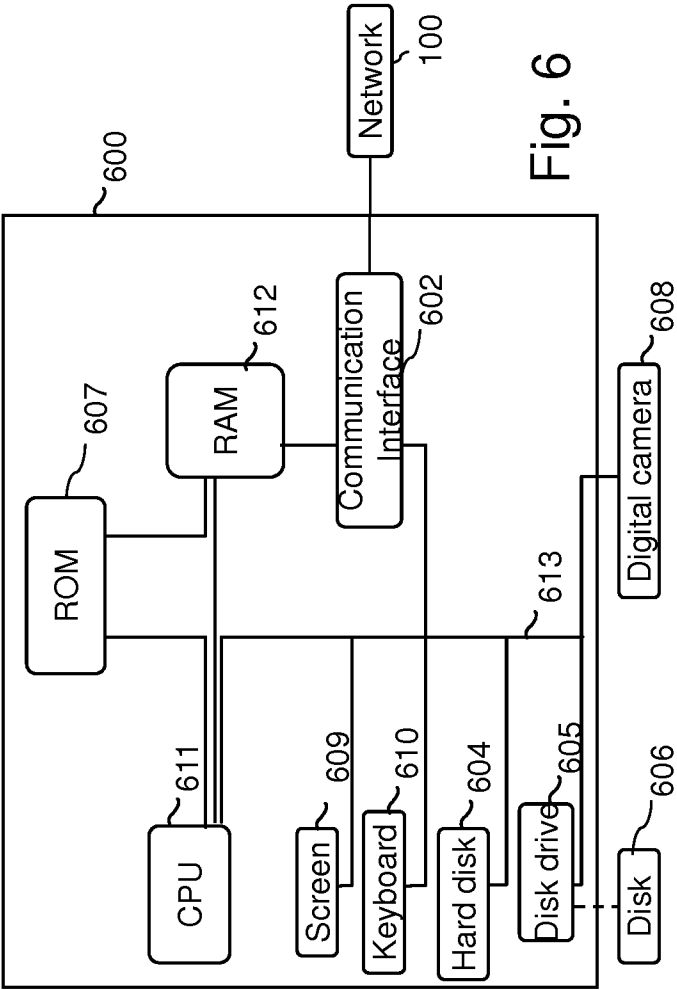
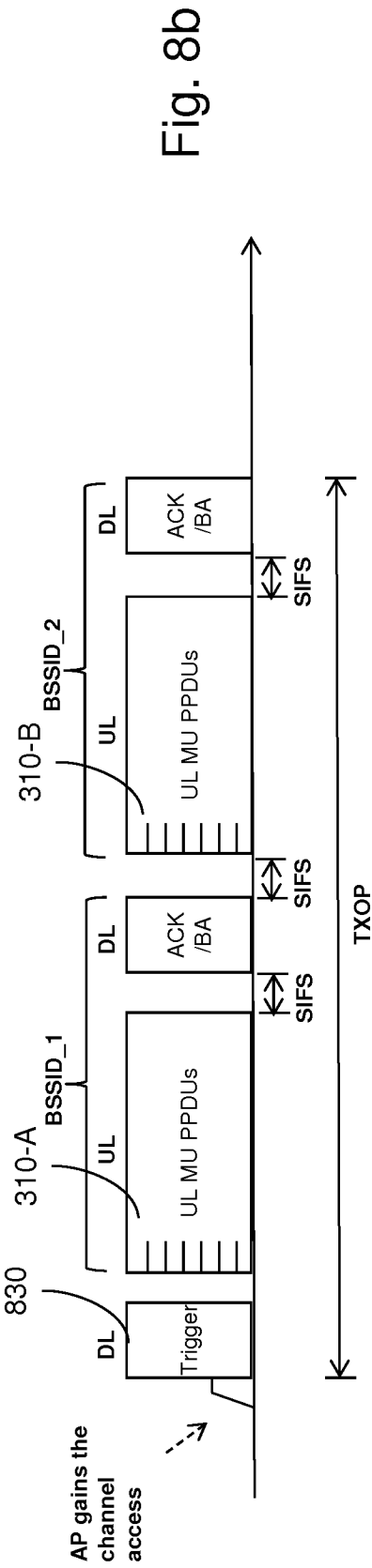
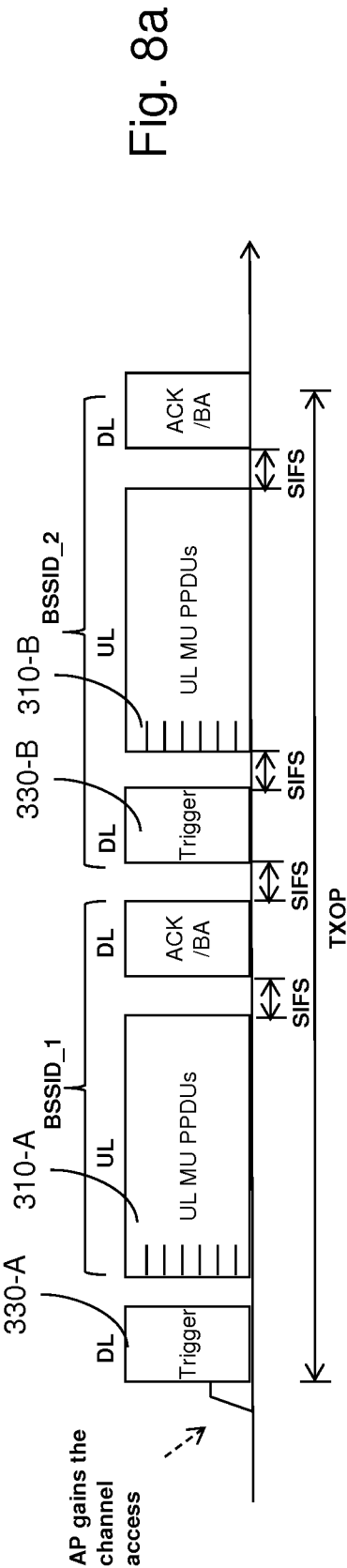
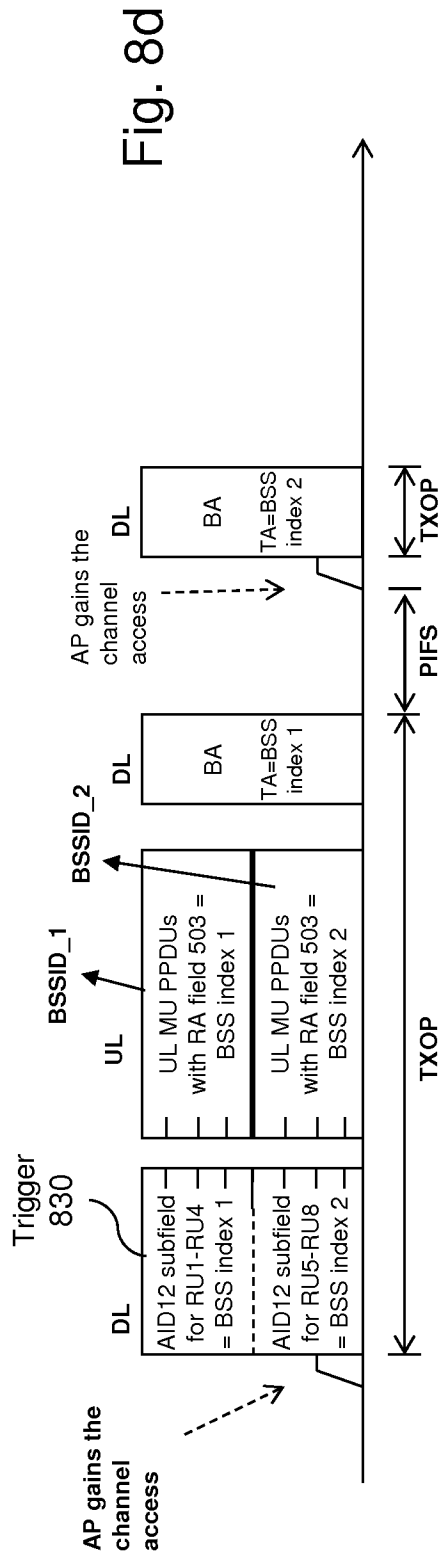
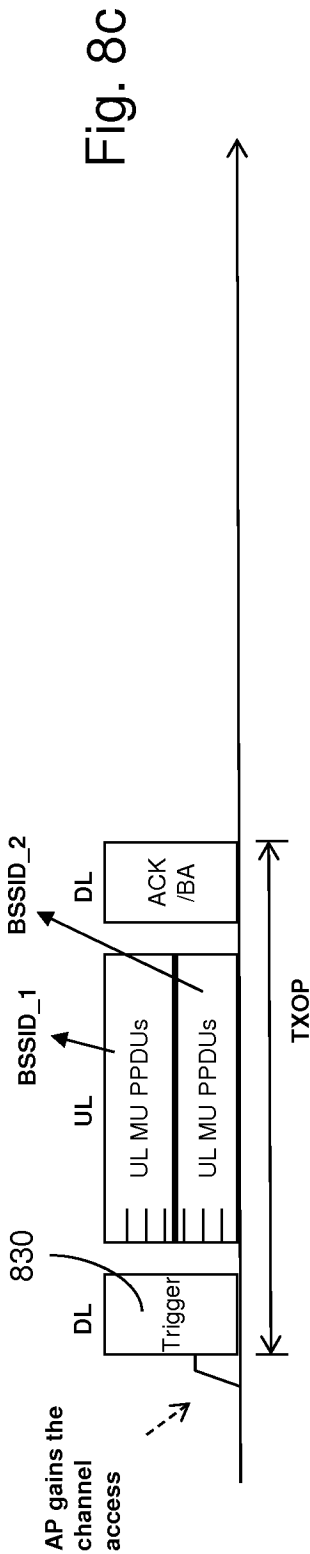
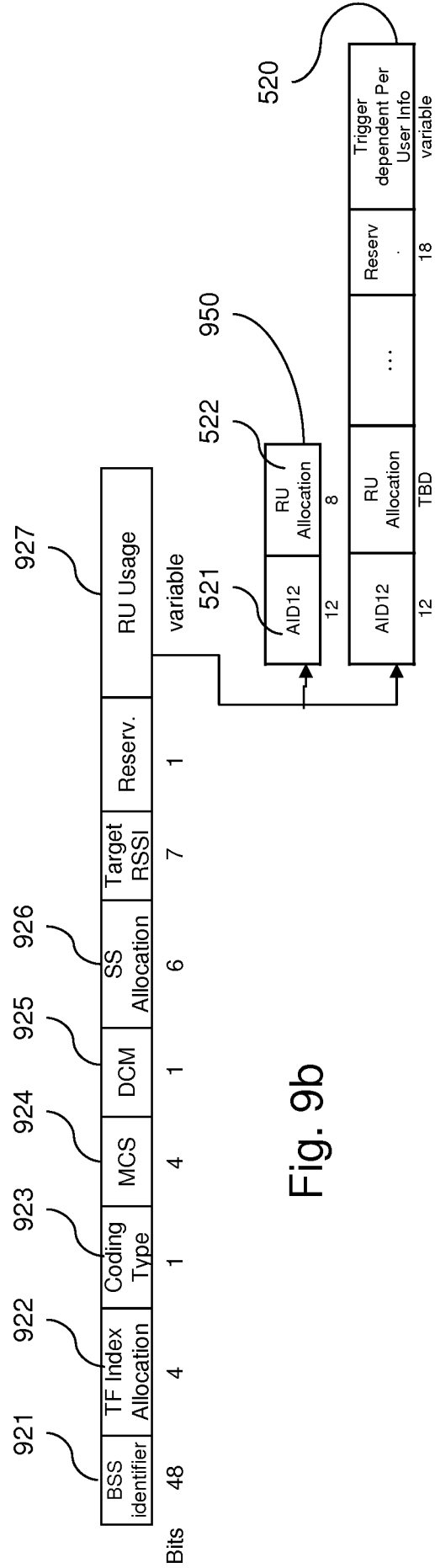
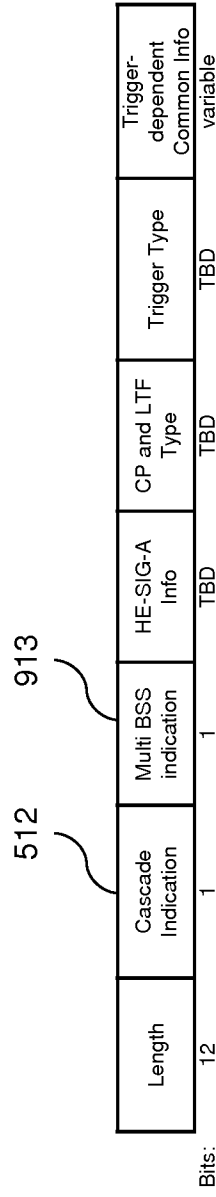
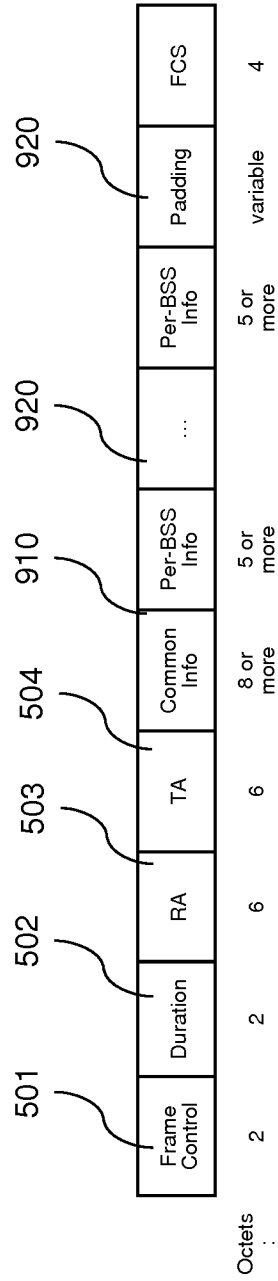


Fig. 6







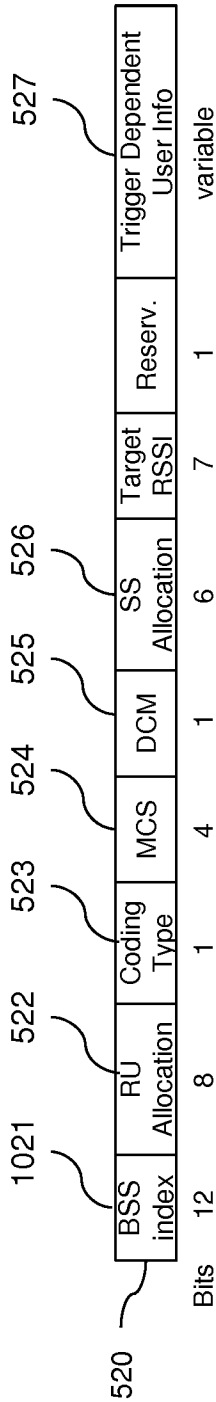
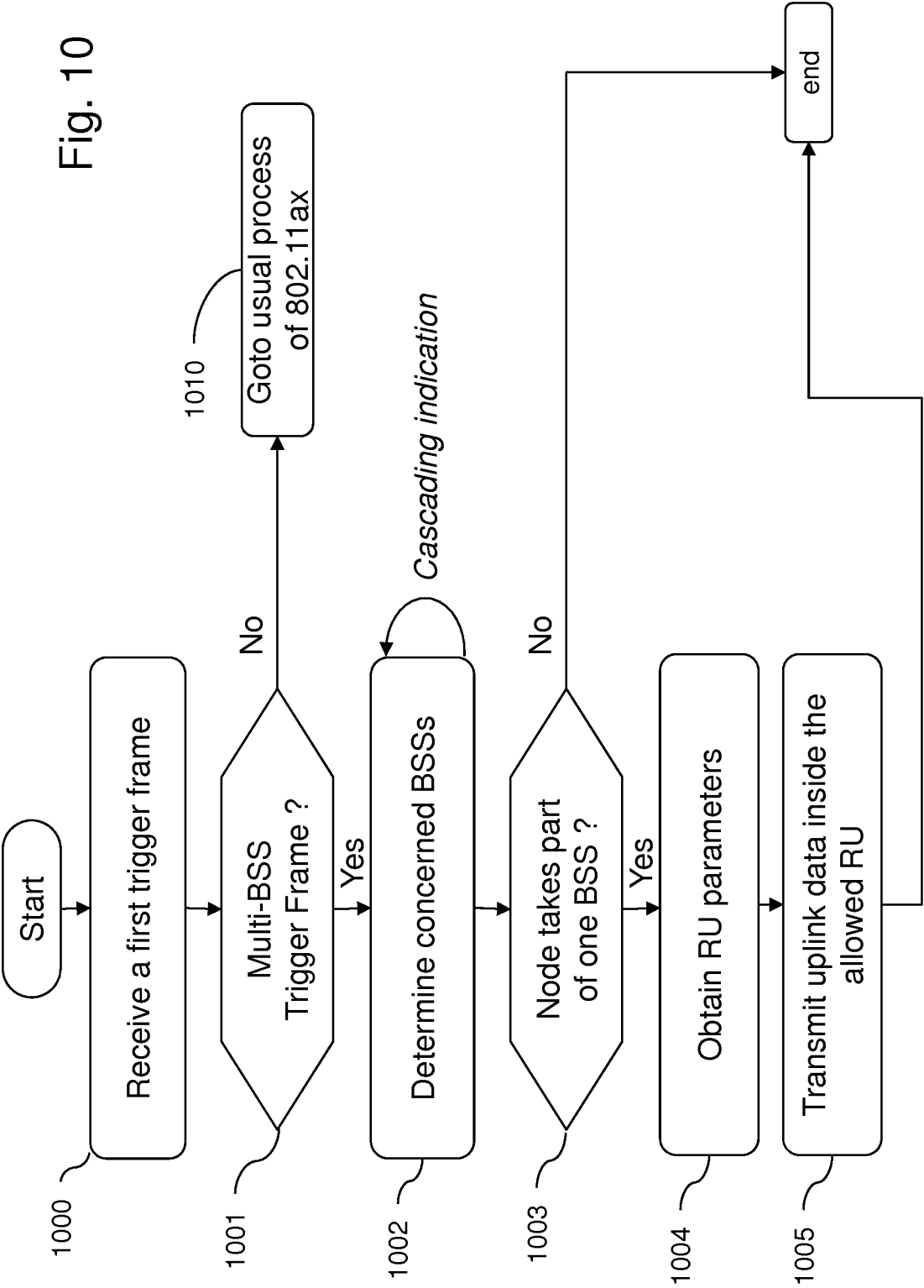


Fig. 9c

Fig. 10



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/070985

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W74/00
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

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

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

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 548 155 A (CANON KK [JP]) 13 September 2017 (2017-09-13) page 3 - page 9 page 20	1-17
X	----- US 2018/199271 A1 (VIGER PASCAL [FR] ET AL) 12 July 2018 (2018-07-12) paragraph [0020] - paragraph [0043]	1-17
A	----- US 2017/230981 A1 (RYU KISEON [KR] ET AL) 10 August 2017 (2017-08-10) the whole document -----	1-17

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Further documents are listed in the continuation of Box C.

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See patent family annex.

* Special categories of cited documents :

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

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"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

15 October 2019

Date of mailing of the international search report

22/10/2019

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Authorized officer

Boldrini, Stefano

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2019/070985

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