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(56) Documents Cited:
 US 20200267636 A1 US 20200077421 A1
 US 20200029350 A1 US 20180176787 A1
 US 20120195244 A1

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(54) Title of the Invention: **Low latency reliable service management in a BSS**
 Abstract Title: **LOW LATENCY COMMUNICATION TRAFFIC MANAGEMENT FOR AN ACCESS POINT**

(57) An access point (AP) which contends for access to a wireless medium in a provision period 403 prior to a start of a low latency (LL) service period (SP) 400 dedicated for transmitting low latency (LL) traffic; upon access the AP reserves an AP transmission opportunity (TXOP) 404 encompassing the LL SP to allow for transmission of LL traffic during the LL SP. The AP may allocate a resource unit during the LL SP and may transmit a first frame 410 including a signalling that the LL SP starts before the end of the AP transmission opportunity. The AP may send an indication to stations for setting their Network Allocator Vector (NAV) so first stations set their NAV to end with the AP transmission opportunity and second stations set their NAV to end prior to the start of the LL SP wherein the second stations may be restricted to transmit only LL traffic during the LL SP. A wireless communication device and non-transitory computer-readable medium are also claimed.

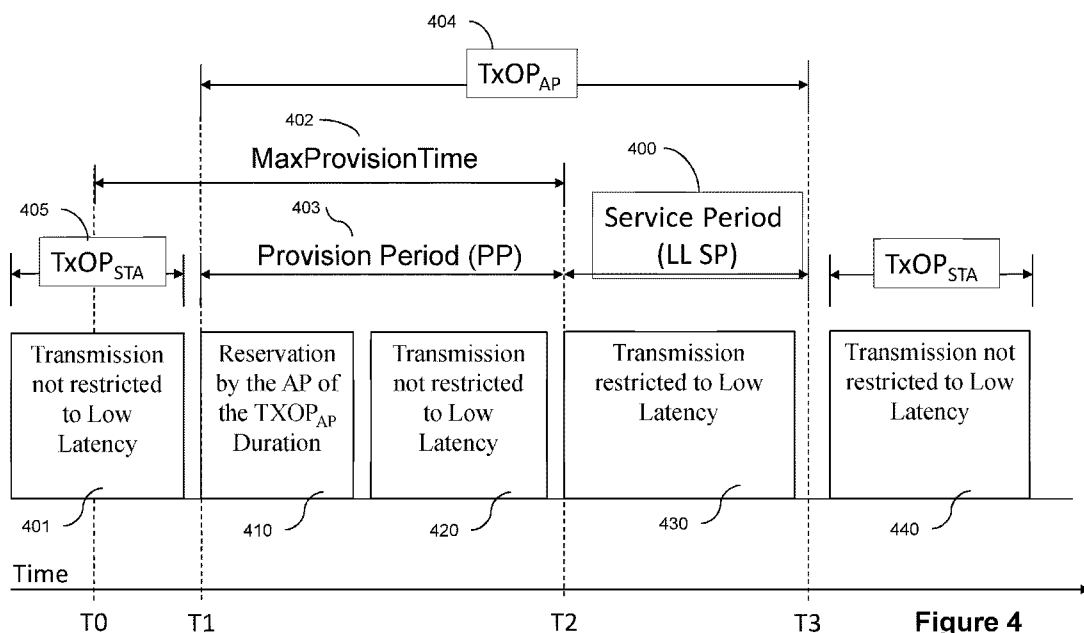


Figure 4

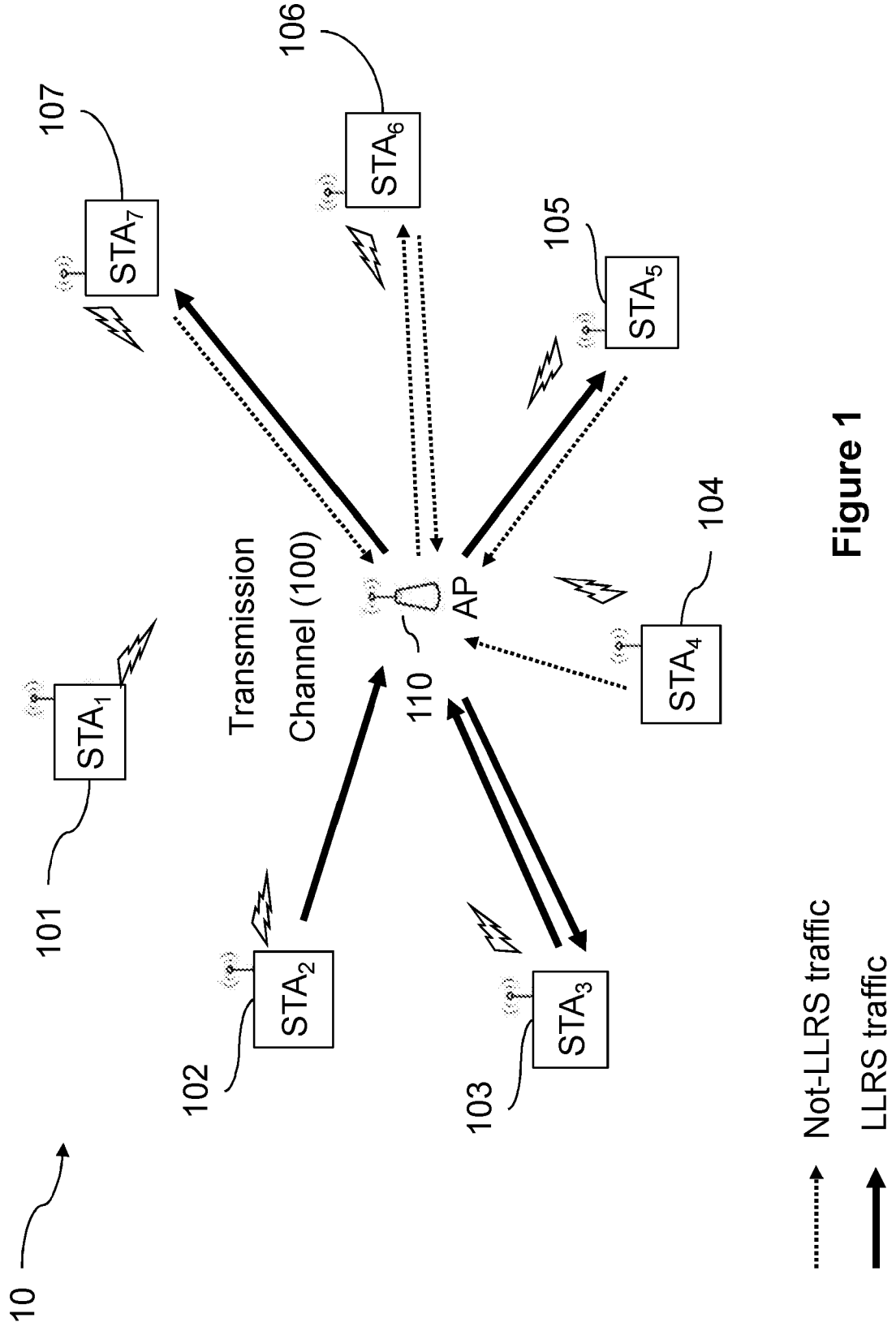


Figure 1

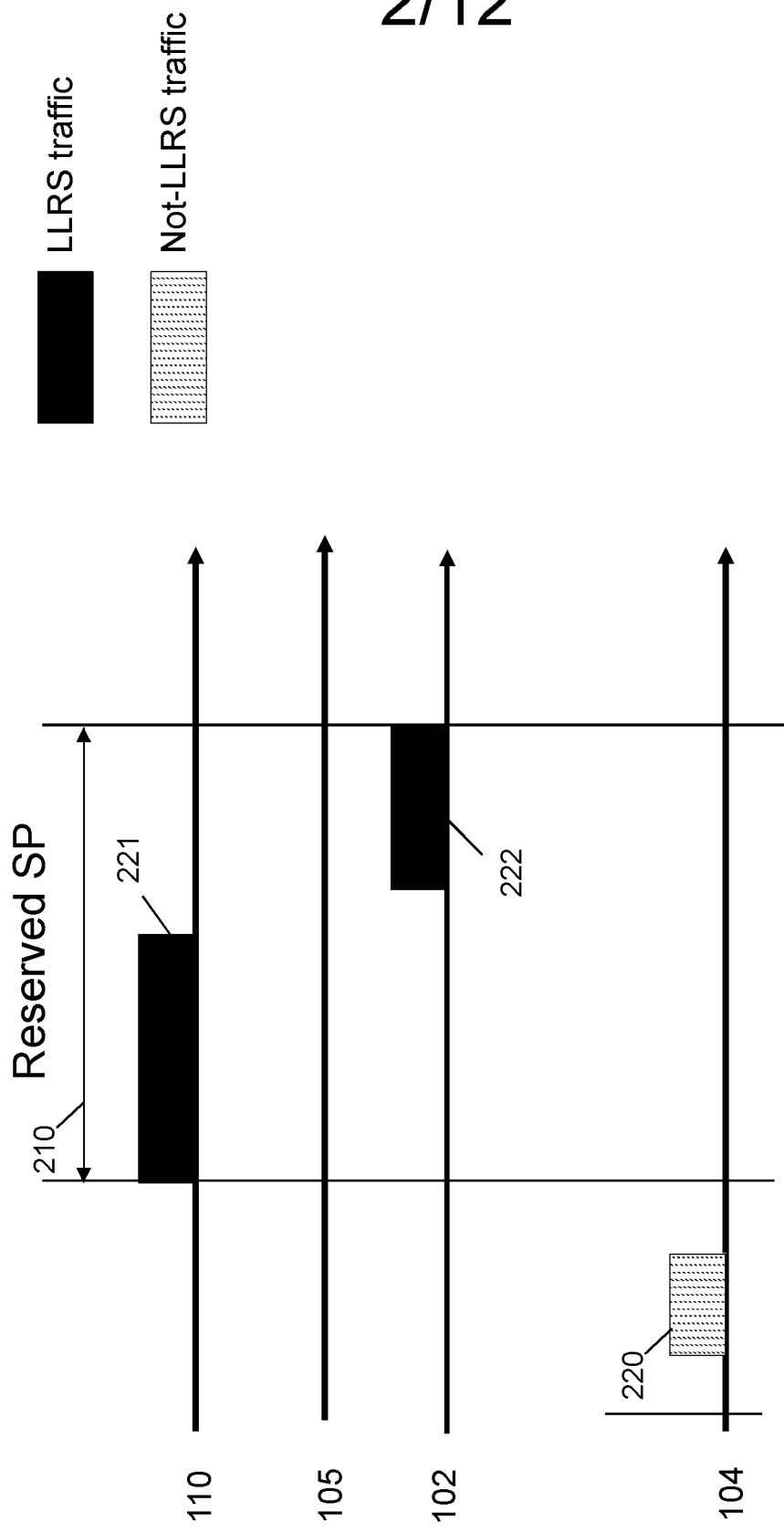


Figure 2

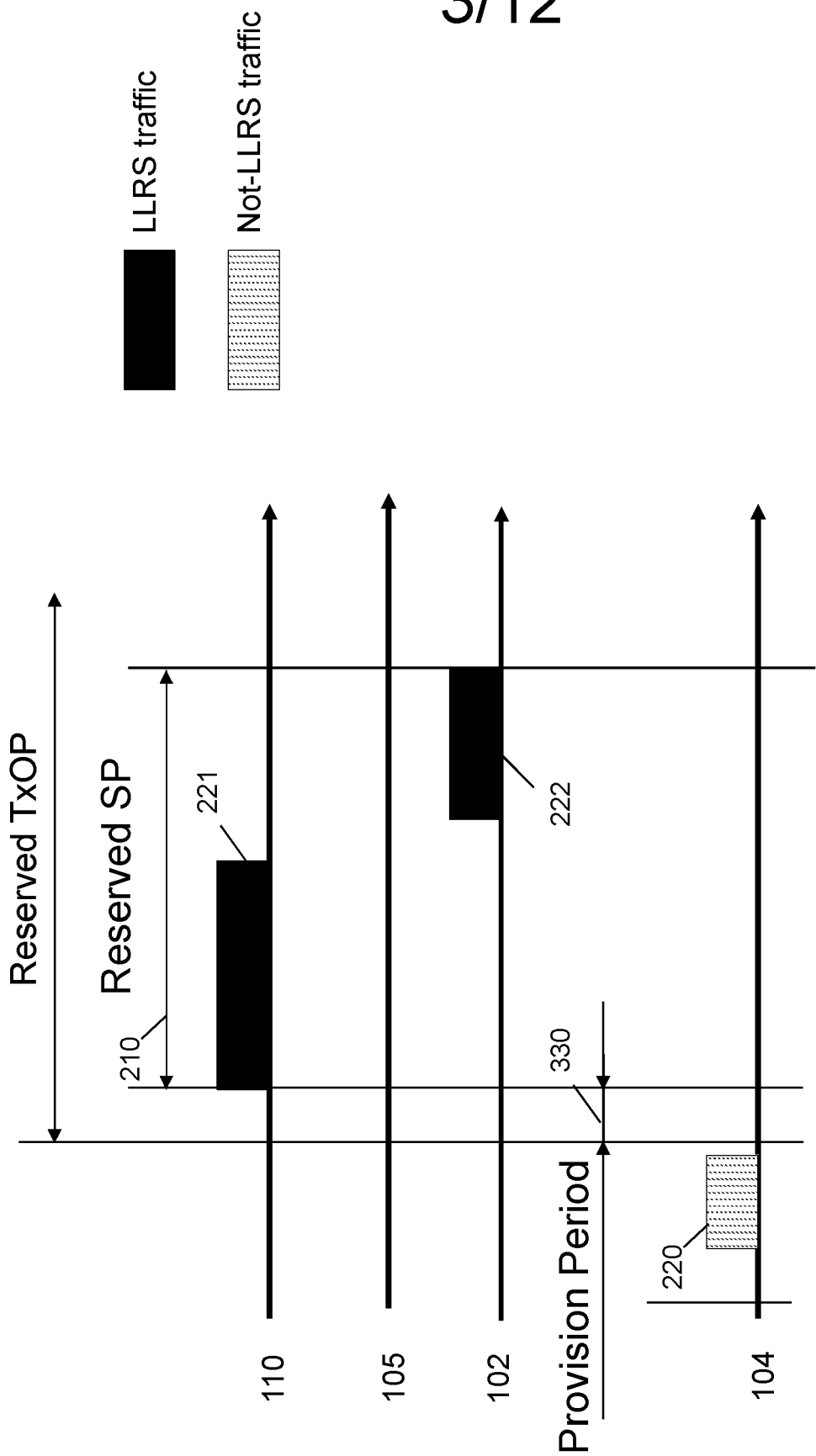


Figure 3

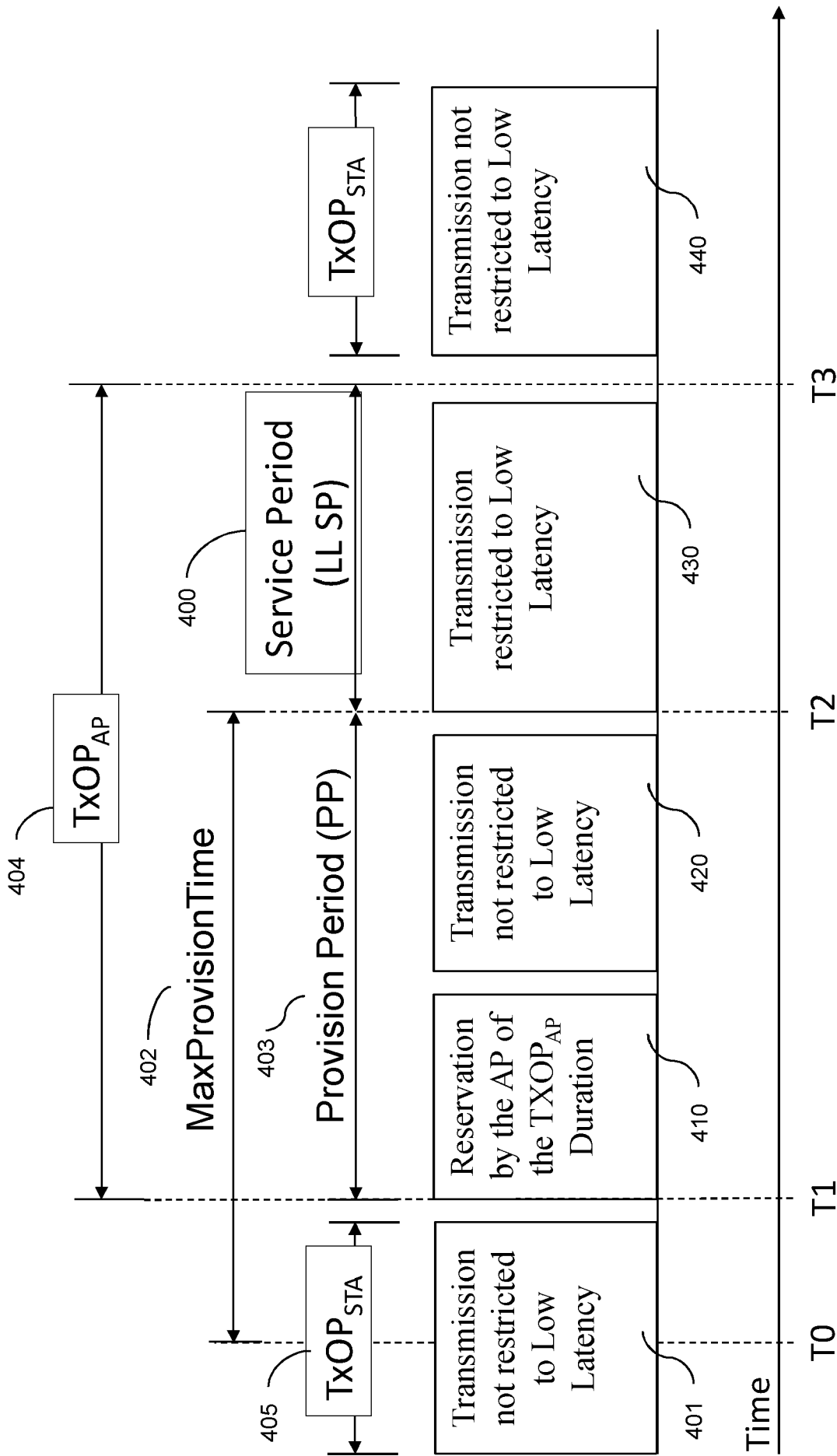


Figure 4

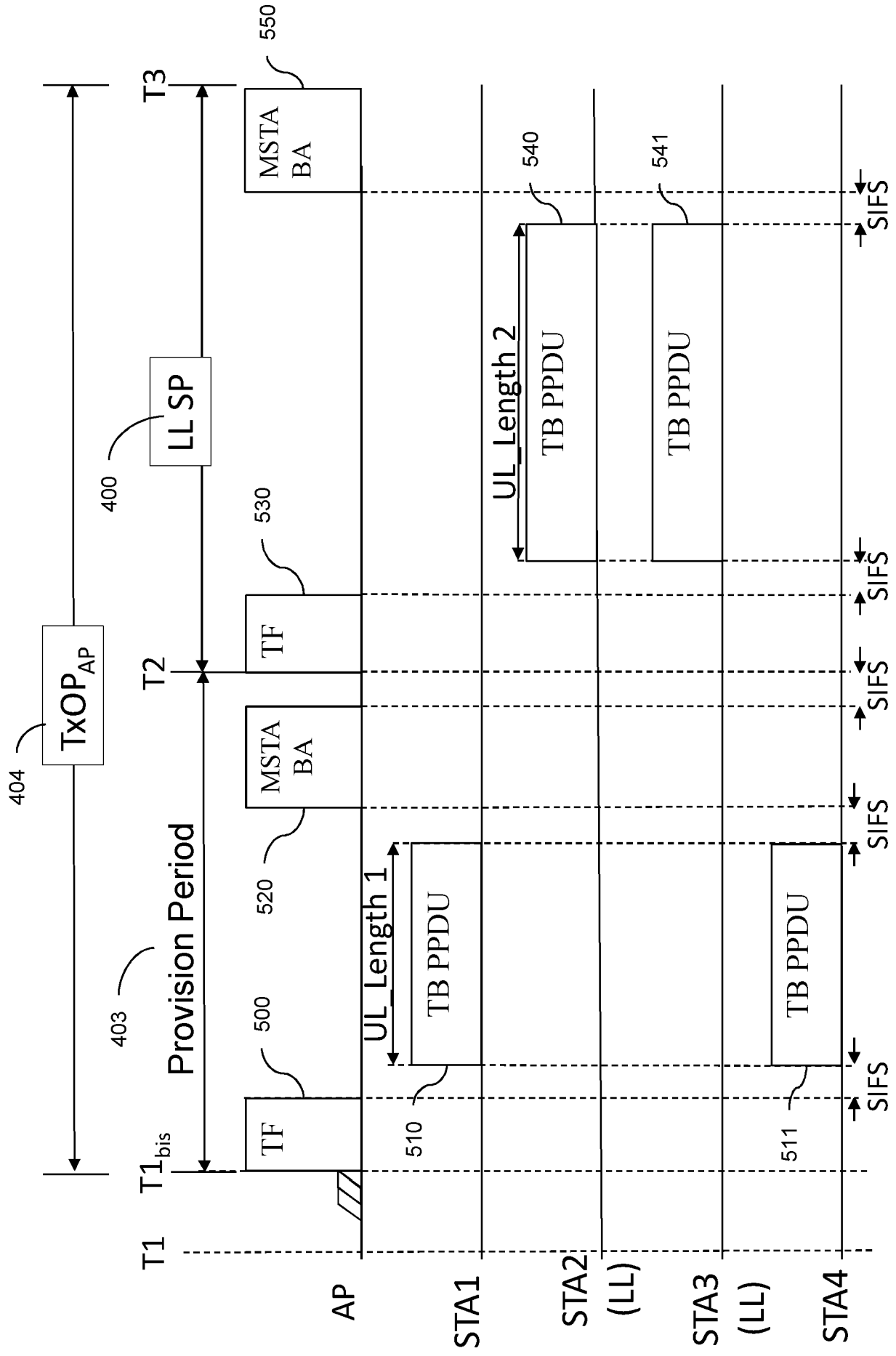


Figure 5a

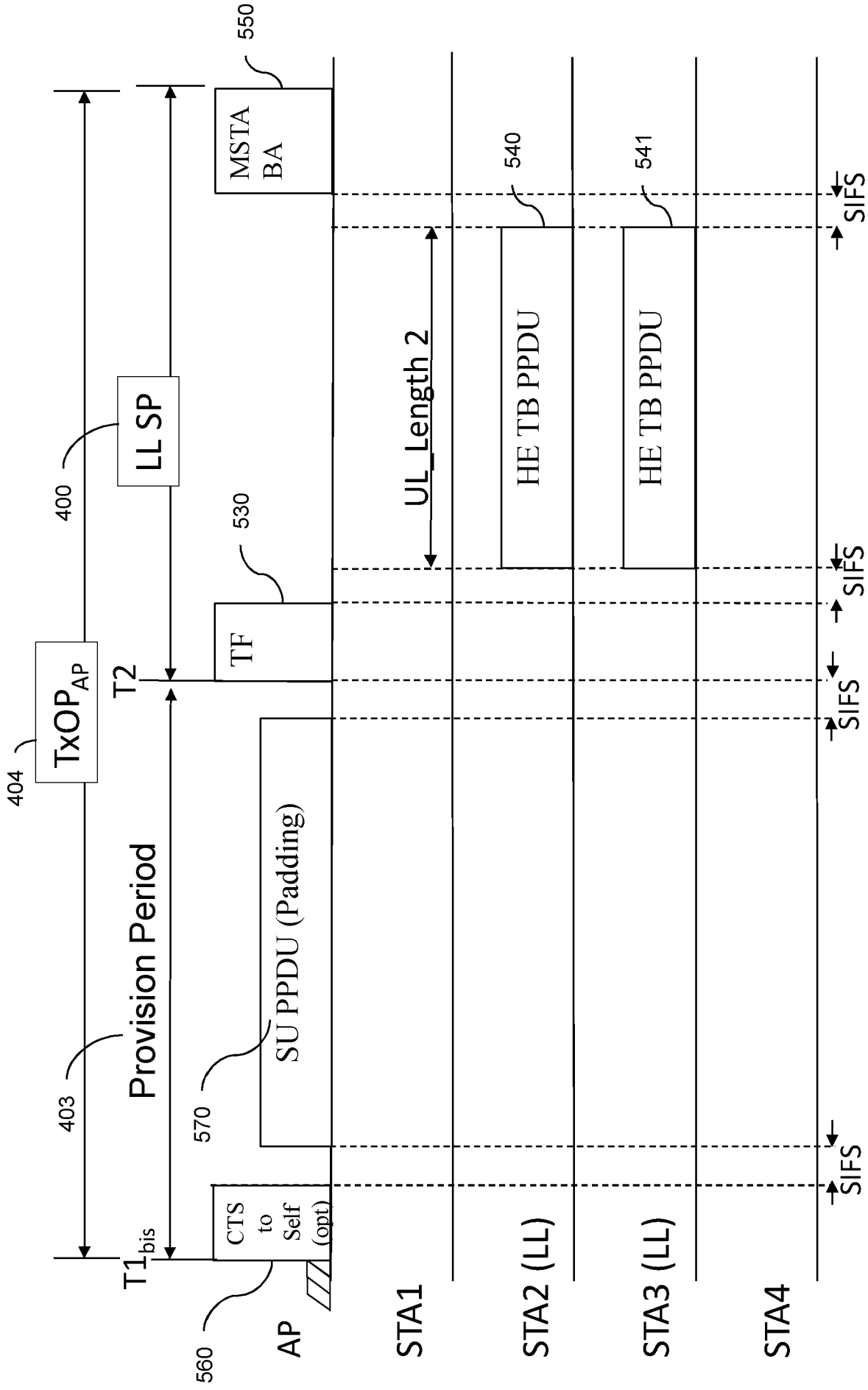


Figure 5b

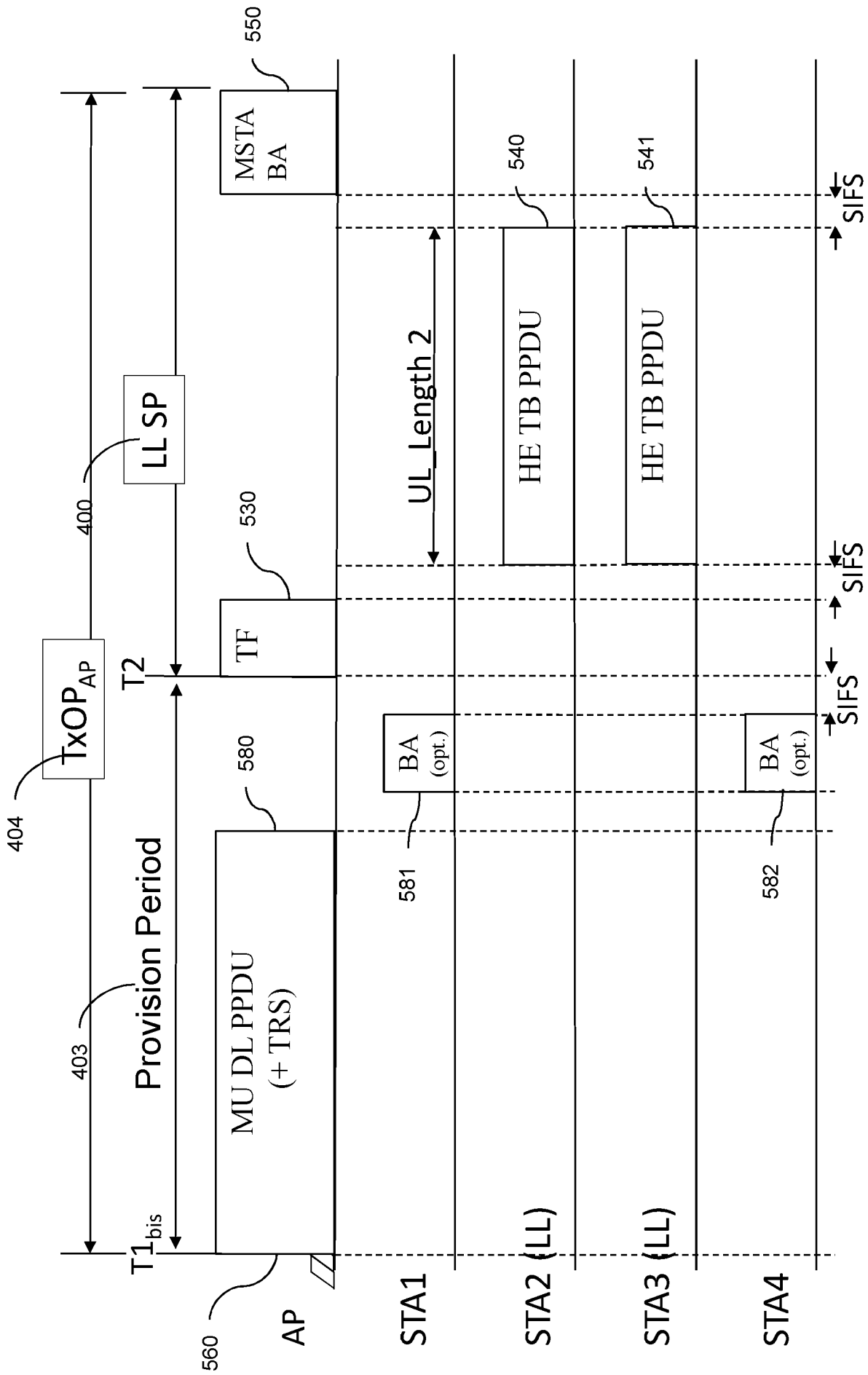


Figure 5c

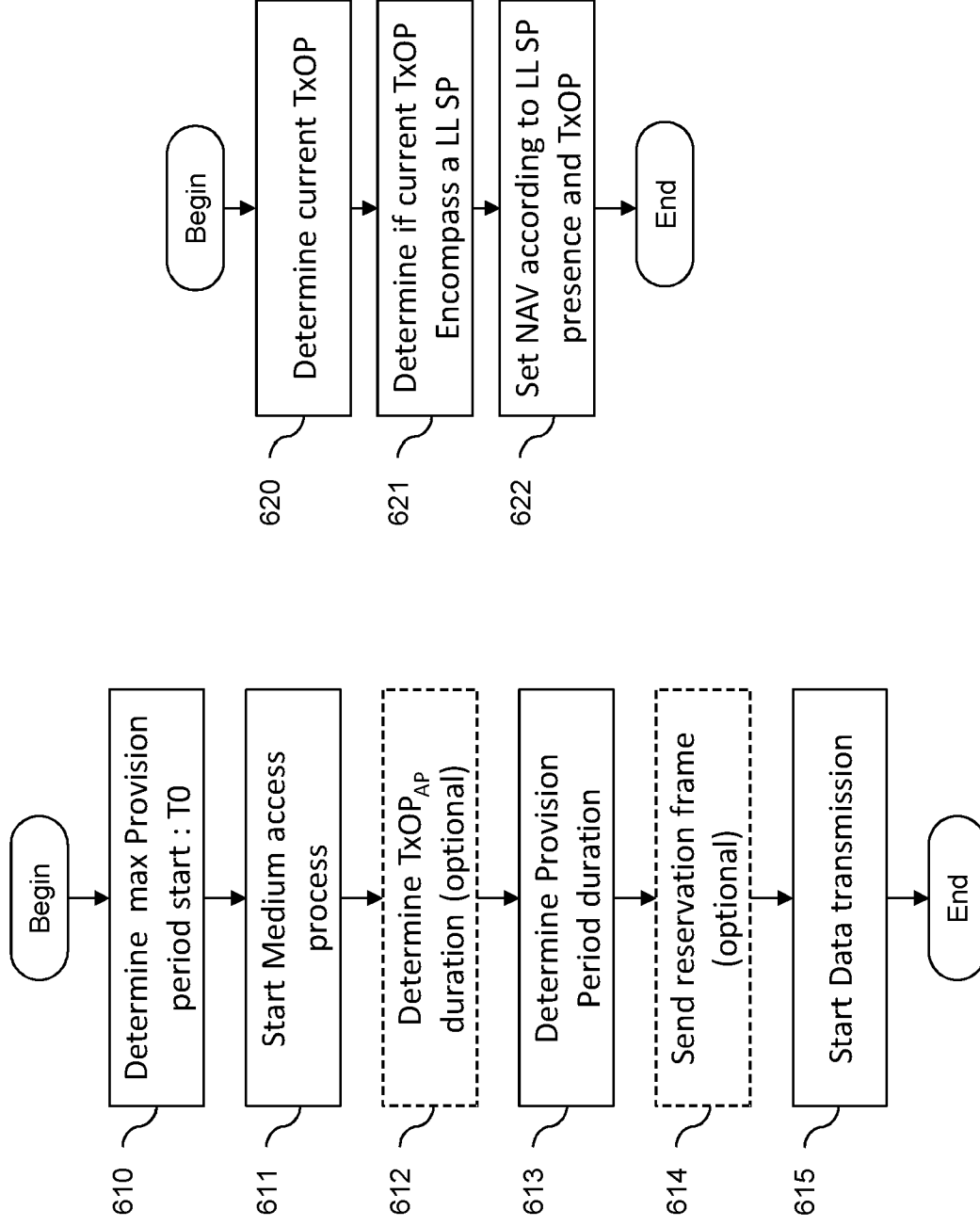


Figure 6a

Figure 6b

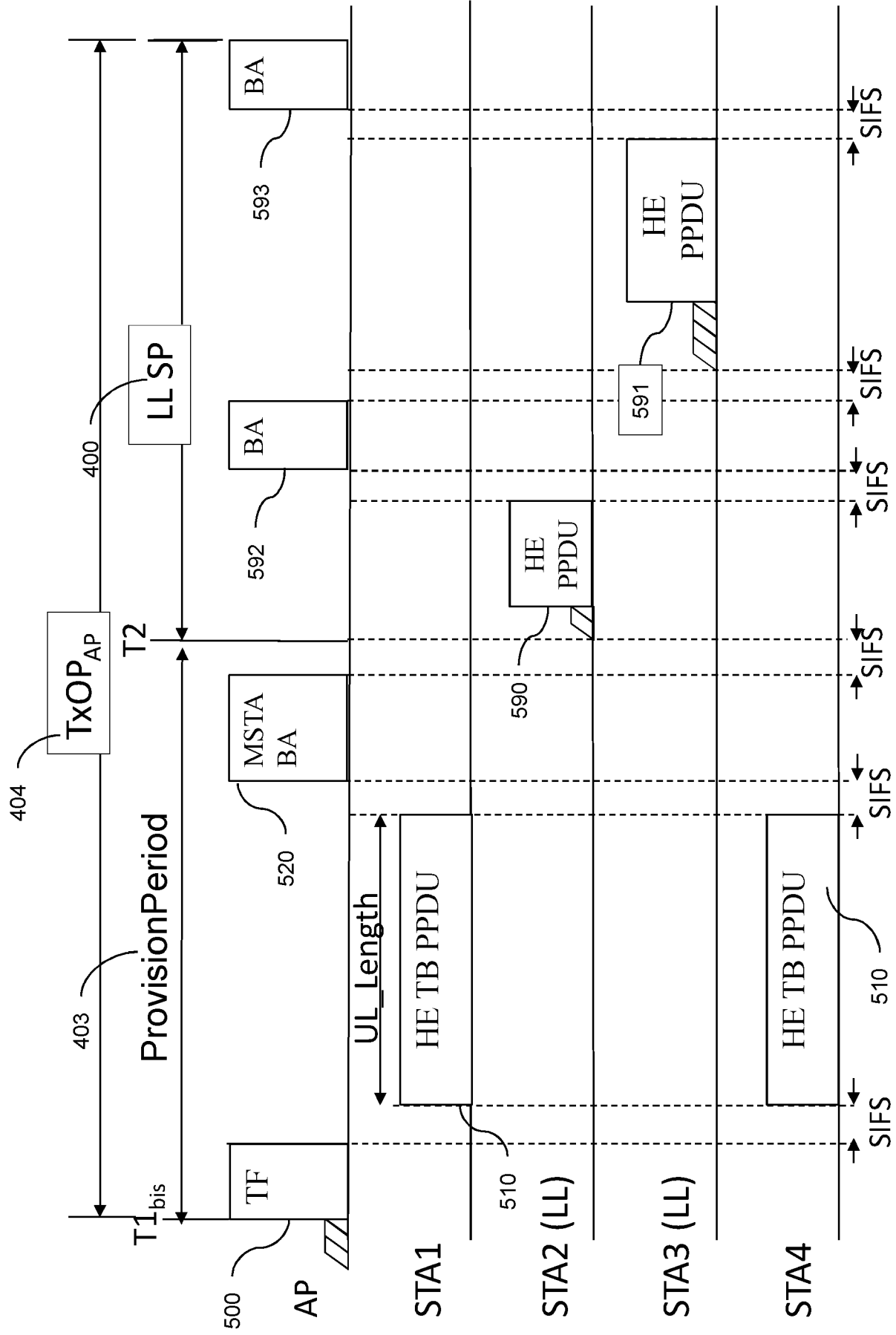


Figure 7

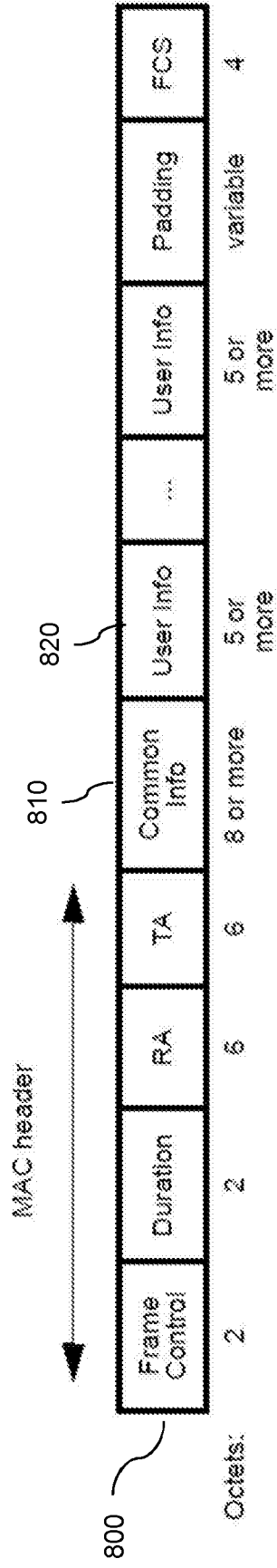


Figure 8a

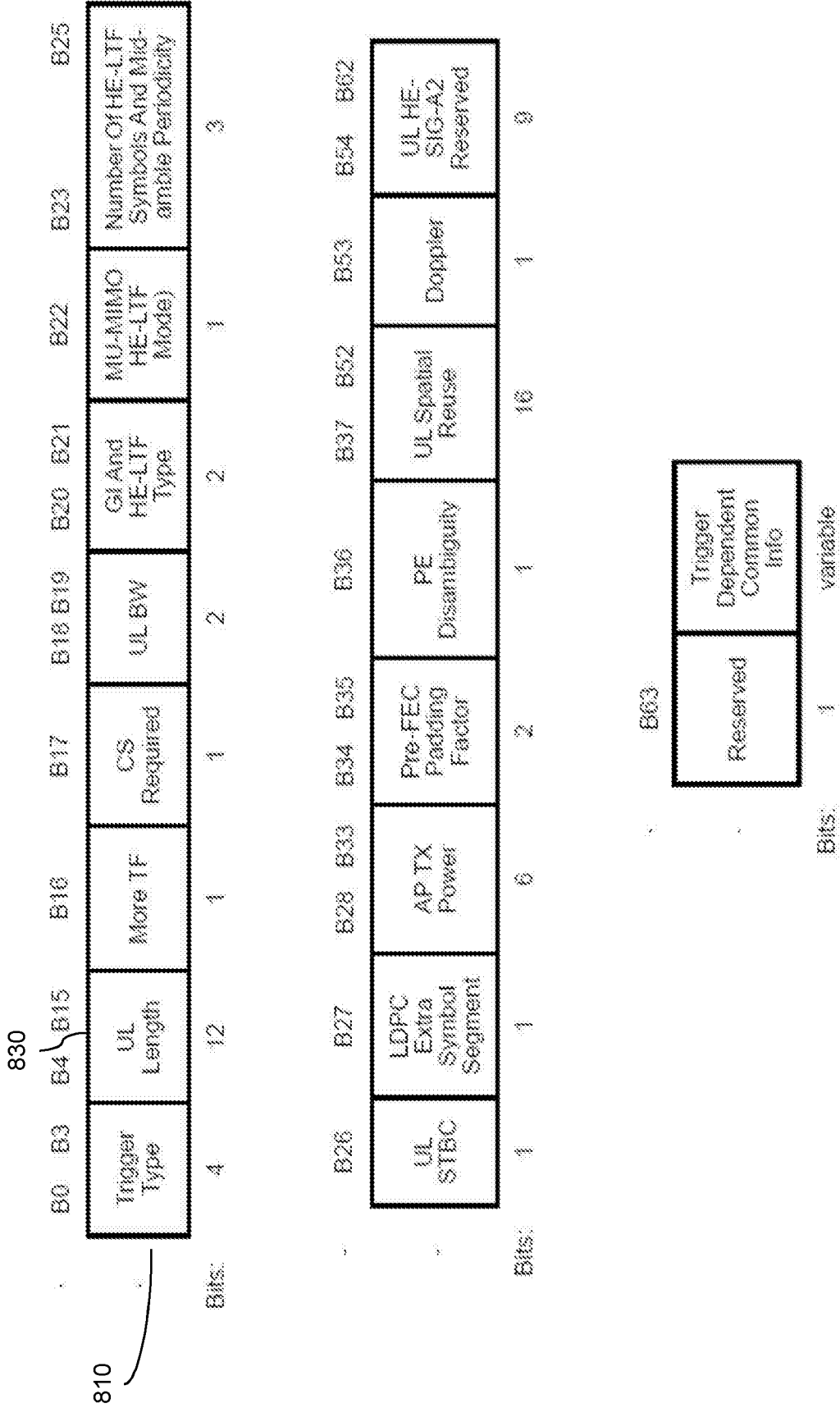


Figure 8b

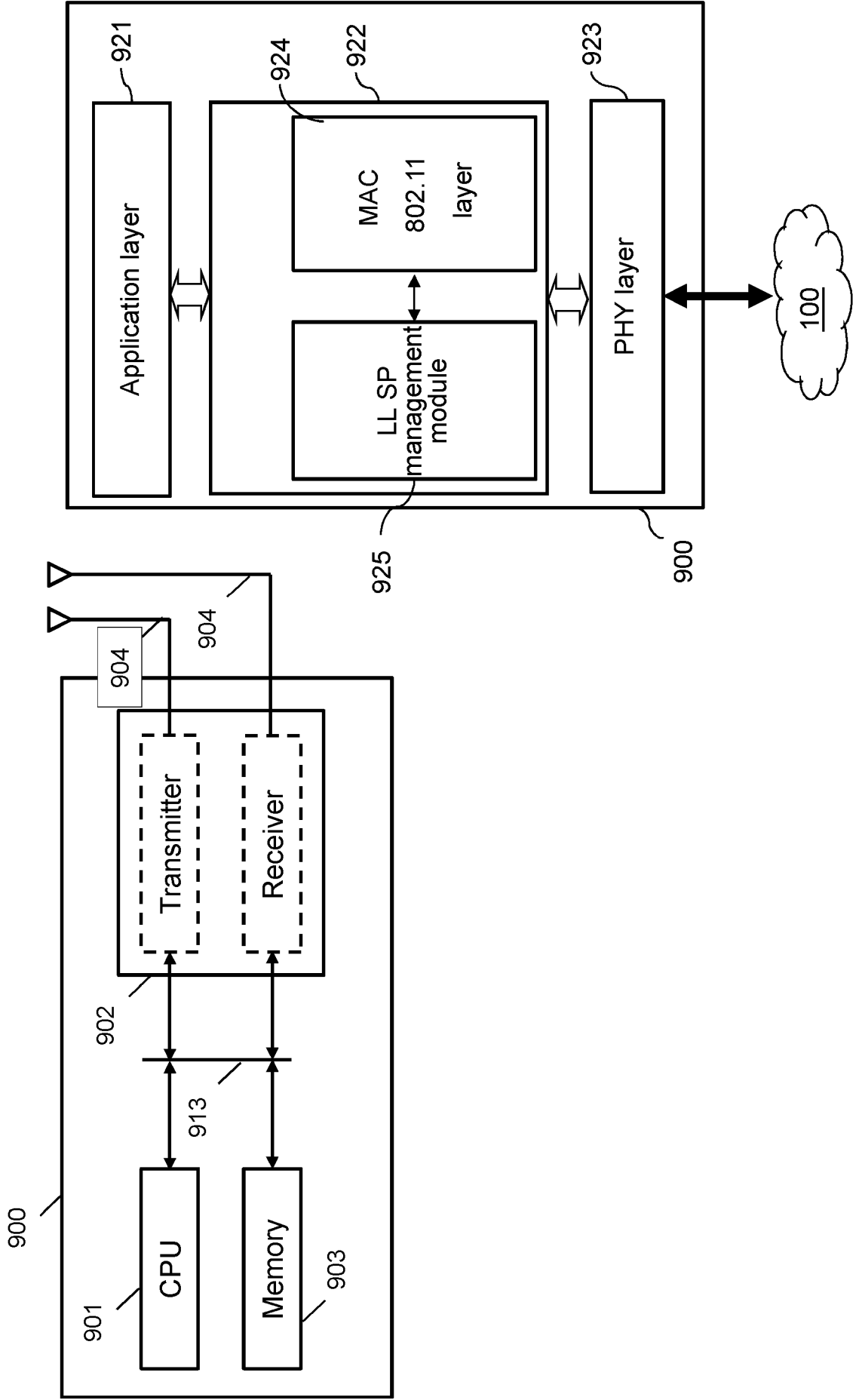


Figure 9b

Figure 9a

LOW LATENCY RELIABLE SERVICE MANAGEMENT IN A BSS

FIELD OF THE INVENTION

The present invention generally relates to wireless communications.

5

BACKGROUND OF THE INVENTION

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) networks, Frequency Division Multiple Access (FDMA) networks, Orthogonal FDMA (OFDMA) networks, and Single-Carrier FDMA (SC-FDMA) networks.

The 802.11 family of standards adopted by the Institute of Electrical and Electronics Engineers (IEEE - RTM) provides a great number of mechanisms for wireless communications between stations.

With the development of latency sensitive applications such as online gaming, real-time video streaming, virtual reality, drone or robot remote controlling, better low latency and robustness requirements and issues need to be taken into consideration. For instance, 99,9% of latency sensitive packets should be delivered to the end equipment within a 2 ms latency.

Such problematic issues are currently under consideration by the IEEE 802.11 working group as a main objective to issue the next major 802.11 release, known as 802.11be or EHT for "Extremely High Throughput".

Low latency reliable services, LLRS, have been defined as targets of such main objective. LLRSs are services provided to a higher layer traffic stream that prioritize and deliver MSDUs (data units) within a worst-case latency budget with a given reliability/packet delivery ratio (PDR) and low jitter.

An efficient QoS management in a BSS (Basic Service Set) is required to provide low latency, LL, reliable services.

30

SUMMARY OF INVENTION

One key issue for an efficient LLRS management in a BSS is for the AP to apply measures to guarantee a starting time of a service period dedicated to LLRS traffic transmission without being subject to contention time contingency for accessing the medium.

The present invention thus proposes a communication method in a wireless network, comprising at an access-point, AP:

contending for access to a wireless medium, a provision period prior a start of a low latency, LL, service period, SP, dedicated for transmitting LL traffic; and

upon gaining access to the wireless medium, reserving an AP transmission opportunity encompassing the LL SP, thereby allowing transmission of LL traffic during the LL SP.

5 In particular, the AP further allocating a resource unit during the LL SP for the transmission of the LL traffic.

In one implementation, the AP further sending an indication to stations for setting their Network Allocator Vector, NAV, the indication causing first stations to set their NAV to end with the AP transmission opportunity and second stations to set their NAV to end prior the start of the LL SP.

10 In a variant, second stations are restricted to transmit only LL traffic during the LL SP. This new mechanism allows the second stations to be ready to transmit or receive at T2 (starting time of the LL SP).

In one implementation, the method further comprising, at the AP, transmitting a first frame, and wherein the first frame including a signalling that the LL SP starts before the end of the AP transmission opportunity.

15 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 wireless device, causes the wireless device to perform any method as defined above.

20 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
25 having computer usable program code embodied in the medium.

30 Since the present invention can be implemented in software, the present invention 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 RF signal.

BRIEF DESCRIPTION OF THE DRAWINGS

35 Embodiments of the invention will now be described, by way of example only, and with reference to the following drawings in which:

Figure 1 illustrates a network environment in which embodiments of the invention may be implemented;

Figure 2 illustrates use of a service period (SP) to prioritize LLRS traffic over not-LLRS traffic within a BSS;

Figure 3 illustrates the use of a provision period by an AP to take control of the wireless medium and to enable scheduling transmissions during a service period restricted to LL traffic;

Figure 4 illustrates a time sequence for scheduling the starting time of a LL service period according to embodiments of the invention;

Figures 5a, 5b and **5c** describe implementations of embodiments of the invention by illustrating combination examples about the way the AP may handle the Provision Period and the Service Period;

Figure 6a illustrates, using a flowchart, operations of the AP according to embodiments of the invention;

Figure 6b illustrates, using a flowchart, operations of a LL STA according to embodiments of the invention at the start of a Provision Period;

Figure 7 illustrates, a time sequence to schedule precisely the starting time of the Low Latency Service according to another implementation of the invention;

Figure 8a illustrates the format of a trigger frame as described in the 802.11ax standard to perform MU UL OFDMA transmissions;

Figure 8b illustrates the format of Common Info field as described in the 802.11ax standard to perform MU UL OFDMA transmissions;

Figure 9a schematically illustrates a communication device; and

Figure 9b is a block diagram schematically illustrating the architecture of the communication device.

DETAILED DESCRIPTION OF EMBODIMENTS

The techniques described herein may be used for various broadband wireless communication systems, including communication systems that are based on an orthogonal multiplexing scheme. Examples of such communication systems include Spatial Division Multiple Access (SDMA) system, Time Division Multiple Access (TDMA) system, Orthogonal Frequency Division Multiple Access (OFDMA) system, and Single-Carrier Frequency Division Multiple Access (SC-FDMA) system. A SDMA system may utilize sufficiently different directions to simultaneously transmit data belonging to multiple user terminals, i.e. wireless devices or stations. A TDMA system may allow multiple user terminals to share the same frequency channel by dividing the transmission signal into different time slots or resource units, each time slot being assigned to different user terminal. An OFDMA system utilizes orthogonal frequency division multiplexing (OFDM), which is a modulation technique that partitions the overall system bandwidth into multiple orthogonal sub-carriers or resource units. These sub-carriers may also be called tones, bins, etc. With OFDM, each sub-carrier may be independently modulated with data. A SC-FDMA system may utilize interleaved FDMA (IFDMA) to transmit on sub-carriers that

are distributed across the system bandwidth, localized FDMA (LFDMA) to transmit on a block of adjacent sub-carriers, or enhanced FDMA (EFDMA) to transmit on multiple blocks of adjacent sub-carriers.

5 The teachings herein may be incorporated into (e.g., implemented within or performed by) a variety of apparatuses (e.g., stations). In some aspects, a wireless device or station implemented in accordance with the teachings herein may comprise an access point (so-called AP) or not (so-called non-AP station or STA).

10 An AP may comprise, be implemented as, or known as a Node B, Radio Network Controller ("RNC"), evolved Node B (eNB), 5G Next generation base station (gNB), Base Station Controller ("BSC"), Base Transceiver Station ("BTS"), Base Station ("BS"), Transceiver Function ("TF"), Radio Router, Radio Transceiver, Basic Service Set ("BSS"), Extended Service Set ("ESS"), Radio Base Station ("RBS"), or some other terminology.

15 A non-AP station may comprise, be implemented as, or known as a subscriber station, a subscriber unit, a mobile station (MS), a remote station, a remote terminal, a user terminal (UT), a user agent, a user device, user equipment (UE), a user station, or some other terminology. In some implementations, a STA may comprise a cellular telephone, a cordless telephone, a Session Initiation Protocol ("SIP") phone, a wireless local loop ("WLL") station, a personal digital assistant ("PDA"), a handheld device having wireless connection capability, or some other suitable processing device connected to a wireless modem. Accordingly, one or more
20 aspects taught herein may be incorporated into a phone (e.g., a cellular phone or smart phone), a computer (e.g., a laptop), a tablet, a portable communication device, a portable computing device (e.g., a personal data assistant), an entertainment device (e.g., a music or video device, or a satellite radio), a global positioning system (GPS) device, or any other suitable device that is configured to communicate via a wireless or wired medium. In some aspects, the non-AP station
25 may be a wireless node. Such wireless node may provide, for example, connectivity for or to a network (e.g., a wide area network such as the Internet or a cellular network) via a wired or wireless communication link.

30 An AP manages a set of stations that together organize their accesses to the wireless medium for communication purposes. The stations (including the AP) form a service set, here below referred to as basic service set, BSS (although other terminology can be used). A same physical station acting as an access point may manage two or more BSS (and thus corresponding WLANs): each BSS is thus uniquely identified by a specific basic service set identification, BSSID and managed by a separate virtual AP implemented in the physical AP.

35 Low latency reliable services, LLRS, are services provided to a higher layer traffic stream that prioritize and deliver MSDUs (data units of this traffic stream) within a worst-case latency budget with a given reliability/packet delivery ratio (PDR) and low jitter. Traffic that may be concerned by LLRS includes latency sensitive data, i.e. data from applications such as gaming, media streaming, augmented reality, virtual reality, and so on.

Figure 1 illustrates an exemplary network environment 10 for delivering LLRS traffic.

Each communication station 101-107 registers to a central station or access point (AP) 110 during an association procedure where the AP assigns a specific Association Identifier (AID) to the requesting non-AP station. For example, the AID, e.g. a 16-bit value uniquely identifying the non-AP station, is used to identify the stations in the frame exchanged. The AP 110 and the associated non-AP stations 101-107 may represent a basic service set (BSS) or an extended service set (ESS).

Once associated with the BSS, the communication stations 101-107, 110 exchange data frames over a radio transmission channel 100 of a wireless local area network (WLAN), under the management of the 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.

Non-AP stations may also communicate directly via a direct wireless link (DiL for direct link), i.e. without the intervention of the AP as relay of their messages. Exemplary situation of direct communications includes the presence of peer-to-peer (P2P) transmissions between non-AP stations having the same primary channel.

The stations 101-107, 110 compete one against the other using EDCA (Enhanced Distributed Channel Access) contention, to gain access to the wireless medium 100 in order to be granted a transmission opportunity (TXOP) and then transmit (single-user, SU) data frames. The stations may also use a multi-user (MU) scheme in which a single station, usually the AP 110, is allowed to schedule a MU transmission, i.e. multiple simultaneous transmissions to or from other stations, during a TXOP granted in the wireless network. One implementation of such a MU scheme has been for example adopted in IEEE 802.11ax amendment standard, as the Multi-User Uplink and Downlink OFDMA (MU UL and DL OFDMA) procedures.

The non-AP stations may represent various devices such as gaming client, augmented/virtual reality headset, smartphones, wireless display and some of them have to exchange (i.e. transmit or/and receives) low-latency or LLRS traffic over time. LLRS traffic has more constrained QoS requirements regarding for instance PDR, jitter and latency, than not-LLRS traffic coexisting in the WLAN 10.

30

To prioritize LLRS traffic over not-LLRS traffic within a BSS, a service period (SP) is reserved for LLRS traffic (also referred to as LL SP) as illustrated by **Figure 2**.

In the illustration, the AP schedules a reserved service period 210. The AP may announce the starting time and the ending time of the period. The reserved service period 210 may be fully dedicated to LLRS traffic exchange, or in variant may allow both LLRS traffic and not-LLRS traffic. In the figure, it is a reserved LLRS period.

35

The AP participates to the LLRS traffic exchange (sends 221 to non-AP station 105 and then receives 222 from non-AP station 102) in the reserved service period. However, this is

not mandatory. The reserved LLRS period may alternatively be used by non-AP stations to directly exchange P2P LLRS traffic.

For illustration, previously to the reserved service period, non-AP station 104 gains access to the wireless medium 100 and may start transmitting not-LLRS traffic 220. AP 110 can
5 next transmit LLRS traffic 221 to non-AP station 105 and then receives other LLRS traffic 222 from non-AP station 102.

However, measures need to be applied to guarantee the starting time of the service period without being subject to contention time contingency for accessing the medium, i.e. to ensure that the medium is available for LLRS traffic transmission at the time it is needed.
10

In embodiments of the invention, the reserved service period is a protected Target Wake Time (TWT) service period (referred to as TWP SP or LL TWT SP).

Target Wake Time enables devices to determine when and how frequently they will wake up to send or receive data. TWT allows an AP to manage activity in the network, in order to
15 minimize medium contention between Stations (STAs), and to reduce the required amount of time that an STA in the power-save mode needs to be awake. Thanks to this mechanism, the TWT requesting STA can doze except during the TWT service period (SP) intervals.

TWT SPs can be either individually agreed or broadcast. An individual TWT SP is a specific time or set of times negotiated between two individual stations (referred to as TWT
20 requesting STA and TWT responding STA) and at which the stations are expected to be awake in order to exchange frames with each other. During negotiations, they transmit to each other a special information element (TWT IE) which contains TWT parameters and can be interpreted as request, suggestion, demand, alternation, acceptation, dictation, or rejection. Either the AP or the STA can tear down the TWT by transmitting a TWT Teardown frame. The broadcast TWT is
25 similar to an individual TWT except that the specific time or set of times are not negotiated between stations but directly broadcast by an AP to multiple non-AP stations, e.g. using a beacon frame. In that case, the AP uses another mechanism based on a TIM element to indicate the set of STAs towards which the AP is going to transmit (Downlink data – DL) or which the AP is going to trigger for uplink traffic. If a STA is not indicated in a TIM element, it means that it will not be
30 solicited within the next TWT SP.

However, an established TWT SP itself does not forbid other STAs to access the channel. So, TWT does not provide contention-free channel access and the STAs transmit frames in TWT SPs using legacy channel access methods.

35 The foregoing concerns are addressed according to an aspect of the invention by considering an AP-centric approach in which the AP takes measures to guarantee timely transmission of LL traffic during the LL SP.

According to this aspect, one measure is for the AP to start contending access to the medium a provision period (PP) prior the start of the service period so that to increase chances

of taking control of the medium. The AP may increase chances by taking a longer PP and optionally setting a transmission opportunity parameter of the AP much greater (e.g. 2 or 3 times) than the transmission opportunities of the stations so that the transmission opportunity of the AP encompasses both PP and SP. As there is a maximum time limit of the transmission opportunity setting, the AP may shorten the transmission opportunities of the stations in addition or in combination.

Figure 3 illustrates a provision period 330 during which the AP contends for access to the medium prior the LL SP.

Another measure that may be taken by the AP is to enable scheduling transmissions during the service period that are restricted to LL traffic. Implementation of this method may be that the AP allocates resources for LL traffic transmission (e.g. by allocating multi-user downlink and/or uplink resource units). Another implementation may be that the AP indicates different NAV periods appropriately so that LL STAs still are able to contend for access during the LL SP (e.g. using EDCA) for exchanging LL traffic while non-LL STAs view the medium as busy during that same period.

Figure 4 illustrates a time sequence for scheduling the starting time of a LL service period 400 according to embodiments of the invention.

The following times are considered in these embodiments.

T2 is the starting time of the LL SP 400 as announced by the AP. The announcement may be done for instance by indicating the value T2 in a beacon frame previously transmitted by the AP.

T0 is the starting time of a maximum provision period (MaxProvisionTime) that can be setup at the AP. T0 can be determined by the AP by subtracting MaxProvisionTime 402 from T2:

$$T0 = T2 - \text{MaxProvisionTime.}$$

MaxProvisionTime 402 may for instance be set at system initial setup, e.g. hardcoded according to the network specification, or configured by the administrator of the AP. An example value may be $\text{MaxProvisionTime} = 2 \times \text{TxOPLimit}_{\text{STA}}$, where $\text{TxOPLimit}_{\text{STA}}$ is the maximum value of the Transmission opportunity duration that can be chosen by stations registered with the AP.

T1 indicates the start of the Provision Period (PP) 403. For example, T1 is equal to the first instant at which the medium becomes free after T0. This corresponds to the starting time of the medium access procedure (e.g. EDCA procedure) of the AP that will lead the AP to gain access to the medium for starting transmission at a time T1_{bis} (not illustrated). The AP may take benefit of the Provision Period 403 to communicate with stations not concerned by the coming LL SP, while securing the effective starting time of that LL SP.

T3 corresponds to the end of the LL SP 400.

If an AP gains access to the medium before T₀, the AP maximum transmission opportunity (TxOP_{AP}) is limited by the conventional maximum TxOP value. But if the AP gains access to the medium between T₀ and T₂, the AP is allowed to extend its TxOP value to encompass the duration of the LL SP.

5 In a variant, the value of the TxOP reserved by the AP (TxOP_{AP}) has a fixed value when accessing the medium during the MaxProvisionTime 402.

In one implementation, the AP may start attempting to access the medium from time T₀ even if the AP has no data to transmit nor data to poll from stations in order to secure the start of the LL SP. **Figure 5b**, detailed below, illustrates one variant of this implementation in which the
10 AP sends a data packet with only padding to a virtual station (invalid or non-registered Receiving address set in the RA field of the frame). This variant can also be used when the AP gains access to the medium a very short time before the start of the LL SP which does not allow to have a minimal full transmission (data transmission and corresponding ack reception).

At T₁, the AP starts the medium access mechanism using for example the
15 conventional EDCA procedure. At the end of a successful backoff procedure of the EDCA, the AP gains access to the medium and, at T_{1bis}, the AP starts sending a first frame 410. Frame 410 indicates a transmission opportunity duration (TxOP_{AP} value 404) encompassing the coming LL SP. In the example of **Figure 4**, this TxOP_{AP} value 404 corresponds to the time difference between T₃, that is the end of the LL SP period 400, and T_{1bis}:

$$20 \quad \text{TxOP}_{\text{AP}} = T_3 - T_{1\text{bis}}.$$

In another embodiment, the TxOP_{AP} value 404 can be greater than the former determination (T₃ - T_{1bis}) and allows further transmission by the AP or other STAs in the same TxOP after the end of the LL SP period 400, and before the end of the TxOP_{AP} period 404.

In another embodiment, the TxOP_{AP} value 404 can be fixed (typically 3 x
25 TxOPLimit_{STA}), especially when the LL SP duration is equal to TxOPLimit_{STA} 405.

Figures 5a, 5b and 5c illustrate various implementations for scheduling a provision period and a service period.

Different frame types can be used to signal a TxOP duration by the AP (referred to
30 hereinafter as signaling frame). For instance, the AP may send any kind of trigger frame 500 (as defined by the 802.11ax amendment standard) that initiates a Multi User Uplink transmission, a Multi User Physical Packet Data Unit (MU PPDU) that simultaneously transmit data to multiple receivers, a Request-To-Send (RTS) frame, a Clear-To-Send (CTS) frame 560, a Single User Physical Packet Data Unit (SU PPDU) 570, or any kind of frame initiating a communication with
35 other stations.

By setting the TxOP value (indicating the length of the transmission) to the TxOP_{AP} value 404, the AP indicates to all stations listening the preamble of the frame (registered to the AP or not) that the medium will be busy until the end of the TxOP. Upon reception of this frame, all the stations that should not participate to the LL SP, will set their Network Allocator Vector

(NAV) and then will not try to access the medium until the end of the TxOP value. This protect the effective start of the LL SP period. The NAV is a value that indicates the duration during which the medium will be busy, so if the NAV period didn't expire, a station is not supposed to try to access the medium.

5 In the contrary, upon reception of the signaling frame transmitted by the AP, the stations that should participate and are concerned by the LL SP (as emitter, receiver or both), set their NAV only until T2, without considering the effective value of the TxOP indicated by the AP. This new mechanism allows the stations to be ready to transmit or receive at T2 (starting time of the LL SP).

10 In a variant, this special behavior of stations can be controlled by an LSP indication (LL SP Present) present in the frame transmitted by the AP during the transmission period 410 (reservation period). For example, the frame may contain an indication that the indicated TxOP duration encompasses a LL service period. In this variant, a LL STA that has to LL traffic transmit and/or received during the LL SP 400 checks this indication to determine the actual duration of
15 its NAV as either the value of the TxOP or until T2 if the indication shows that a LL SP is encompassed in the TxOP.

 In order to guarantee the start of the LL SP 400 at T2, the AP stops transmission
420 a Short Inter Frame Space (SIFS) before T2. For that, the AP determines the duration of the Downlink (DL) or Multi User Down Link (MU DL) traffic and corresponding Acknowledgments, or
20 the duration of the triggered Uplink traffic (indicated in the UL_Length field of the frame triggering the MU UL traffic, cf. **Figure 8b**) and associated acknowledgment from the AP.

 At the starting of the LL SP 400, either the AP gains back the medium for a transmission to stations involved in the LL SP, or one of the LL STAs (102 or 103 for instance) accesses the medium.

25 To avoid collision between transmissions of the AP and the LL STAs at the start of the LL SP 400, the AP may optionally include an indicator EDCA_Enabled that indicates, in a frame transmitted by the AP during the transmission period 410, if the LL SP 400 will start with a first transmission by the AP or if the LL SP 400 is available for a classical EDCA medium access from any LL SP STAs, or from a specific LL SP STA. This indication may also be included in the
30 declaration of the LL SP for instance in an information element of a beacon frame.

 In case EDCA_Enabled is false (or is not present and its default value is false), at T2, the AP will initiate the transmission using a trigger frame 530 to trigger Uplink traffic as illustrated in **Figure 5a**, or by initiating Single User (SU) DL or MU DL traffic. The initialization of a down link traffic may optionally include a medium protection sequence like an RTS/CTS exchange or a MU RTS/CTS exchange. Since the medium is normally already protected by the
35 NAV mechanism setup at the beginning of the transmission (reservation) period 410, this optional protection sequence is dedicated to the protection against stations that may be in doze mode during the reservation period 410.

In a variant, if EDCA_Enabled is true (or is not present and default value is true), one or more of the LL STAs will try to access the medium at the starting of the LL SP 400. In order to handle correctly the collision between those stations and potentially between those stations and the AP, LL SP stations may use an alternative set of EDCA parameters values (LL_EDCA Parameter Set) to handle the collision and congestion control during the LL SP. LL_EDCA Parameter Set may contain one or more different (adapted) values of the EDCA parameters like TxOPLimit indicating the maximum duration of a LL SP transmission, AIFS that indicates the minimum waiting time before counting down the EDCA backoff counters, the maximum congestion window value used to randomly select the EDCA backoff counters, or other EDCA parameters. In another variant, the EDCA medium access during the LL SP period may rely on a dedicated EDCAF (EDCA Function) that handles dedicated backoff counters and could apply different medium access rules.

At the end of the TxOP_{AP} period 404, conventional EDCA medium access mechanism may be executed by any station (including the AP) to gain access to the medium and start a new transmission period 440 not restricted to Low Latency traffic. In a variant, at the end of the LL SP 400 and prior the end of the TxOP_{AP} period 404, transmission not restricted to Low Latency traffic may be performed under the control of the AP.

Figure 5a illustrates, a time sequence to schedule precisely the starting time of the Low Latency Service Period (LL SP 400) according to an implementation of the invention where the Provision Period 403 is used by the AP to trigger a Multi User Uplink communication with the regular (non-LL) stations, and initiate the LL SP 400 by a trigger Frame (TF) 530 to poll Low Latency stations in a Multi User Uplink communication.

In this implementation, at T_{1bis}, the AP gains the medium, compute the duration of the TxOP, and sends a trigger frame 500 that reserve the medium for a TxOP_{AP} 404 duration. The TF 500 optionally contains the LSP indication and/or the EDCA_Enabled indication. In this example, if the LSP indication is present, this indication is set to true and the EDCA_Enabled indication (if present) is set to False. Those indications are typically present in the Common Info field 810 (**Figure 8a**) of the TF 500.

The trigger frame 500 also indicates the duration UL_Length 1 of the triggered PPDU 510 and 511 in the field UL_Length 830 (**Figure 8a**). This duration being determined by the AP to guaranty that the medium is free at T₂. Typically, $UL_Length1 = T_2 - T_{1bis} - (TF\ 500\ duration) - 3 \times SIFS - (MSTA\ BA\ 520\ duration)$; where MSTA BA 520 is a Multi station Block Ack. The AP is able to determine those durations since it knows the modulation scheme used and the size of the corresponding packets (both TF 500 and MSTA BA 520).

Upon reception of the TF 500, the non-LL (regular) stations STA1 and STA4 addressed by the AP in the TF 500 send a Trigger Based PPDU (TB PPDU) (respectively 510 and 511) using the transmission parameters received in the TF 500 in the User Info Field addressed to regular stations.

The AP then transmits a Multi Station Block Ack 520 to acknowledge the received TB PPDU.

A SIFS after the end of the transmission of the MSTA BA 520, the AP initiates the LL SP by sending a TF 530 that addresses LL Stations (STA2 and STA3 in this example). The TF 530 indicates a new duration UL_Length 2 for the TB PPDU 540 and 541. The AP then finishes the LL SP period by acknowledging the received TB PPDU in a MSTBA 550.

Figure 5b illustrates, a time sequence to schedule precisely the starting time of the Low Latency Service Period (LL SP 400) according to an implementation of the invention where the Provision Period 403 is used by the AP to send data to a single regular station, and initiate the LL SP 400 by a trigger Frame (TF) 530 to poll Low Latency stations in a Multi User Uplink communication.

In this example, the AP initiates the Provision Period 403 by sending a Single User PPDU to a regular station. A protection sequence (CTS to self in the example, RTS/CTS, or MU RTS/CTS) may optionally be present before the start of the SU transmission. This protection sequence may include a frame including the optional indications LSP and/or EDCA_Enabled (for instance in a MU RTS TF as described in the previous implementation, or in a new variant of the RTS or CTS frames).

In an implementation variant of the **Figure 5b**, the SU PPDU 570 may not be addressed to a station (invalid destination address, or destination address corresponding to a station not registered to the AP), and the SU PPDU may contain only padding. This variant allows to keep the medium busy for a short period of time, especially, if the duration of the Provision Period 403 does not permit to setup a full communication (including data transmission and associated acknowledgment) with a regular station.

The rest of the sequence (LL SP period) is identical to the **Figure 5a**.

Figure 5c illustrates, a time sequence to schedule precisely the starting time of the Low Latency Service Period (LL SP 400) according to an implementation of the invention where the Provision Period 403 is used by the AP to send simultaneously data to several regular (non-LL) stations, and initiate the LL SP 400 by Multi User Downlink PPDU 580. This MU DL PPDU may include an indication for the destination regular stations to acknowledge the received PPDU in a multi User Uplink PPDU. For example, this may be done by the AP by integrating a TRS A-Control field in the PPDU addressed to the STA, as described by the IEEE 802.11ax specification.

The destination regular station then acknowledges the received PPDU using the TRS indication.

After the reception of the BA 581 and 582 sent by the regular stations, the AP initiates the LL SP as described in the previous figures.

Figures 5a, 5b and 5c describe implementations of embodiments of the invention by illustrating combination examples about the way the AP may handle the Provision Period 403 and LL SP 400. Of course, other combinations of provision period 403 and LL SP 400 are possible (for instance MU DL PDU during the period 403 and EDCA access during the LL SP 400), but are not all described here.

Figure 6a illustrates, using a flowchart, operations of the AP according to embodiments of the invention.

The algorithm starts upon medium access tentative by the AP. For example, if the AP has data to transmit, or if the AP determines it is time to gain the medium to protect a LL SP.

At step 610, the AP determines the start instant T_0 of the MaxProvision Period. For example, $T_0 = T_2 - \text{MaxProvisionTime}$ as described in **Figure 4**.

At step 611 (T_1 instant), the AP starts the medium access process. For example, if the medium is free, the AP counts down the backoff counter and when the backoff counter reaches 0, the AP accesses the medium (at T_1 bis).

At step 612, the AP determines the duration of the AP transmission opportunity (duration of the total medium reservation). In some embodiments, this value is fixed.

If the start of the medium access process is succeeding T_0 (medium access during the Max provision period), the AP determines the transmission duration that encompasses the LL SP as described in **Figure 4**. For example, $\text{TxOP}_{\text{AP}} = T_3 - T_1^{\text{bis}}$.

At step 613, the AP determines the provision period 403 duration ($\text{TxOP}_{\text{AP}} - \text{LL SP duration}$).

At step 614, the AP prepares and sends a reservation frame (for instance a TF 500, or a CTS 560 as described in the **Figures 5a, 5b or 7**). This step is optional since the data transmission during the Provision Period 403 can directly starts with a data transmission like in the example of **Figure 5c**. In case the reservation frame is present, the content of the reservation frame (e.g. TxOP_{AP} value, presence and value of the optional indications LSP indication and EDCA_Enabled, and the value of the UL_Length field in the case of a trigger frame) is performed as described in **Figures 4, 5a, 5b and 5c**.

At step 615, the AP starts data transmission with the regular (non-LL) stations following one of the embodiments described in **Figures 5a, 5b or 5c**.

Figure 6b illustrates, using a flowchart, operations of a LL STA according to embodiments of the invention at the start of the Provision Period 403.

At step 620, the LL SP station receives the signaling (likely the first) frame of the regular transmission of the provision period. Even if this frame is not addressed to the LL STA, the station decodes the preamble of the frame and thus can determine the duration of the medium reservation indicated by the AP in the TxOP value.

At step 621, the LL STA determines if the current medium reservation encompasses a LL SP. This can be done by checking the presence of an LSP indication in the reservation frame (for instance in case of a trigger frame, the LL Station decodes the common info field and the user info field to determine if the AP reserved one or more of the resource units described in the TF to it).

If the LSP indication is not present, the LL station may determine if the current TxOP encompasses a LL SP by verifying if the starting time of the (following) LL SP (received in a previous beacon for instance) is included in the current TxOP.

If the current TxOP includes a LL SP, the LL STA set its NAV until the starting time of the LL SP, otherwise to the value of the current TxOP (step 622).

Figure 7 illustrates, a time sequence to schedule precisely the starting time of the Low Latency Service Period (LL SP 400) according to an implementation of the invention where the Provision Period 403 is used by the AP to trigger a Multi User Uplink communication with the regular stations as described in figure 5a, and free the medium for the LL STA to access the medium during the LL SP 400 using the EDCA medium access scheme.

In this implementation, the beginning of the sequence (Provision Period 403) is identical to **Figure 5a**, but after the end of the transmission of the MSTA BA, the AP stops transmitting to let LL SP stations contend for access the medium during the LL SP. It is worth noting that here, upon reception of the TF 500, the LL SP stations do not set their NAV until the end of the TxOP_{AP} duration indicated in the TF 500, but only to T2. This lets the LL stations try access the medium on T2.

The LL SP stations may optionally update their EDCA parameter values (as indicated if the **Figure 4**) before T2 using an updated (e.g. adapted) set of values (LL EDCA parameter set) transmitted by the AP for example in the common info field of the TF 500, or in one of the beacons transmitted before the start of the LL SP 400.

In the illustrated implementation, LL STA2 and LL STA3 alternatively access the medium to send uplink data to the AP. Of course, during a LL SP, the number of Low Latency transmissions is only limited by the end of the LL SP and can contain one or more PPDU transmissions from one or more LL STAs.

Figure 8a illustrates the format of a trigger frame as described in the 802.11ax standard to perform MU UL OFDMA transmissions.

The trigger frame 800 contains several fields as defined in the IEEE standard 802.11ax and in particular it includes a single Common Info field 810 (**Figure 8b**) and a plurality of User Info fields 820.

Each User Info field 820 defines the assignment of the RUs defined in the Common Info field 810 to respective non-AP stations 101-107, as well as communication parameters to respect for UL communication with the AP.

Figure 8b illustrates the format of Common Info field as described in the 802.11ax standard to perform MU UL OFDMA transmissions. The Common Info field 810 contains UL Length field 830 for the UL PPDU length.

5 **Figure 9a** schematically illustrates a communication device 900, either a non-AP station 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 900 may preferably be a device such as a micro-computer, a workstation or a light portable device. The communication device 900 comprises a communication bus 913 to which there are preferably
10 connected:

 a central processing unit 901, such as a processor, denoted CPU;

 a memory 903 for storing an executable code of methods or steps of the methods according to embodiments of the invention as well as the registers adapted to record variables and parameters necessary for implementing the methods; and

15 at least one communication interface 902 connected to a wireless communication network, for example a communication network according to one of the IEEE 802.11 family of standards, via transmitting and receiving antennas 904.

 Preferably the communication bus provides communication and interoperability between the various elements included in the communication device 900 or connected to it. The
20 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 900 directly or by means of another element of the communication device 900.

 The executable code may be stored in a memory that may either be read only, a hard disk or on a removable digital medium such as for example a disk. According to an optional
25 variant, the executable code of the programs can be received by means of the communication network, via the interface 902, in order to be stored in the memory of the communication device 900 before being executed.

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

Figure 9b is a block diagram schematically illustrating the architecture of the communication device 900, either the AP 110 or one of stations 101-107, adapted to carry out, at
35 least partially, the invention. As illustrated, device 900 comprises a physical (PHY) layer block 923, a MAC layer block 922, and an application layer block 921.

 The PHY layer block 923 (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 210 (**Figure 4b**) to reserve a transmission slot,

MAC data and management frames based on a 20MHz width to interact with legacy 802.11 stations, as well as of MAC data frames of OFDMA type having smaller width than 20MHz legacy (typically 2 or 5 MHz) to/from that radio medium.

5 The MAC layer block or controller 922 preferably comprises an 802.11 MAC layer 924 implementing conventional 802.11ax MAC operations, and additional block 925 for carrying out, at least partially, the invention. The MAC layer block 922 may optionally be implemented in software, which software is loaded into RAM 912 and executed by CPU 911.

10 Preferably, the additional block 925, referred to as Triggered MU Tx management module for triggered MU transmissions following a medium access trigger frame through OFDMA resource units (sub-channels), implements the part of embodiments of the invention (either from station perspective or from AP perspective).

802.11 MAC layer 924, LL SP management module 925 interact one with the other in order to process accurately the starting and management of the Low Latency Service Periods according to embodiments of the invention.

15 On top of the Figure, application layer block 921 runs an application that generates and receives data packets, for example data packets such as a video stream. Application layer block 921 represents all the stack layers above MAC layer according to ISO standardization.

20 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.

25 Many further modifications and variations will suggest themselves to those versed in the art upon referring 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.

30 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 communication method in a wireless network, comprising at an access-point, AP:
- 5 contending for access to a wireless medium, a provision period prior a start of a low latency, LL, service period, SP, dedicated for transmitting LL traffic; and
 upon gaining access to the wireless medium, reserving an AP transmission opportunity encompassing the LL SP, thereby allowing transmission of LL traffic during the LL SP.
- 10 2. The method of Claim 1, wherein the AP further allocating a resource unit during the LL SP for the transmission of the LL traffic.
3. The method of Claim 1, wherein the AP further sending an indication to stations for setting their Network Allocator Vector, NAV, the indication causing first stations to set their NAV to end with the AP transmission opportunity and second stations to set their NAV to end prior the start of the LL SP.
- 15 4. The method of Claim 3, wherein second stations are restricted to transmit only LL traffic during the LL SP.
5. The method of Claim 1, further comprising, at the AP, transmitting a first frame, and wherein the first frame including a signalling that the LL SP starts before the end of the AP transmission opportunity.
- 20 6. A wireless communication device comprising at least one microprocessor configured for carrying out the steps of the method of Claim 1 or 5.
7. A non-transitory computer-readable medium storing a program which, when executed by a microprocessor or computer system in a wireless device, causes the wireless device to perform the method of Claim 1 or 5.
- 25



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Claims searched: 1-7

Date of search: 22 April 2021

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1, 2 & 5-7	US 2020/0077421 A1 (QUALCOMM) figs. 1, 5A & 6 and paras. [0057], [0115]-[0117], [0125], [0132], [0145], [0150]-[0155], [0160] & [0161]
X	1, 2, 5 & 7	US 2020/0267636 A1 (CAVALCANTI et al) figs. 1, 2, 4-6 & 14 and paras. [0023], [0024], [0032]-[0037], [0064], [0073], [0090] & [0096]
X	1, 2, 5 & 7	US 2020/0029350 A1 (QUALCOMM) figs. 1, 2 & 4B-5D and paras. [0085], [0086], [0092]-[0098], [0103] & [0127]-[0129]
X	1 & 5-7	US 2018/0176787 A1 (QUALCOMM) figs. 2 & 9 and paras. [0045], [0075] & [0076]
A	-	US 2012/0195244 A1 (WENTINK et al.) figs. 1 & 10 and paras. [0027], [0032], [0046] & [0050]

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Field of Search:

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H04L; H04W

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WPI, EPODOC, Patent Fulltext, XP3GPP



International Classification:

Subclass	Subgroup	Valid From
H04W	0074/00	01/01/2009
H04W	0072/04	01/01/2009