US 20250267700A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2025/0267700 A1**

Adhikari et al. (43) **Pub. Date: Aug. 21, 2025**

(54) **LATENCY REDUCTION THROUGH CONTROLLER TRANSMIT OPPORUNITY SHARING**

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(21) Appl. No.: **18/929,178**

(22) Filed: **Oct. 28, 2024**

(30) **Foreign Application Priority Data**

Feb. 15, 2024 (IN) 202421010608
May 7, 2024 (IN) 202421036114

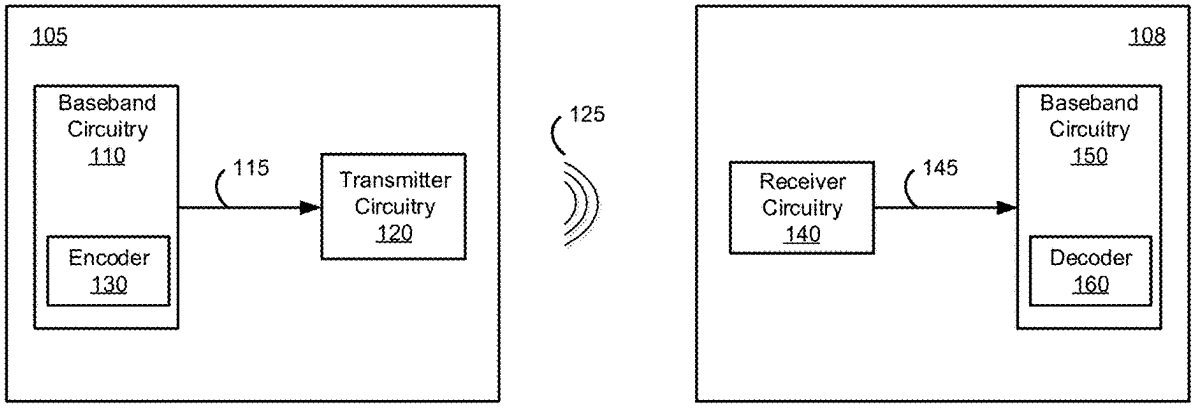
Publication Classification

(51) **Int. Cl.**
H04W 74/02 (2009.01)
H04W 28/02 (2009.01)
H04W 74/00 (2009.01)

(52) **U.S. Cl.**
CPC ***H04W 74/02*** (2013.01); ***H04W 28/0236*** (2013.01); ***H04W 74/006*** (2013.01)

(57) **ABSTRACT**

Technical solutions include systems and methods for transmission opportunity (TXOP) sharing for latency sensitive traffic of non-TXOP holder devices within a TXOP. A first device granted a TXOP can identify a first portion of a TXOP for a transmission of the first device. The first device can determine that a remaining portion of the TXOP subsequent to the first portion is available for data transmissions of other devices. The first device can transmit, to the other devices, an indication of availability of the remaining portion of the TXOP. The first device can allocate, responsive to one or more responses to the indication, the remaining portion of the TXOP to a second device of the one or more other devices to transmit data of the second device during the remaining portion of the TXOP period.



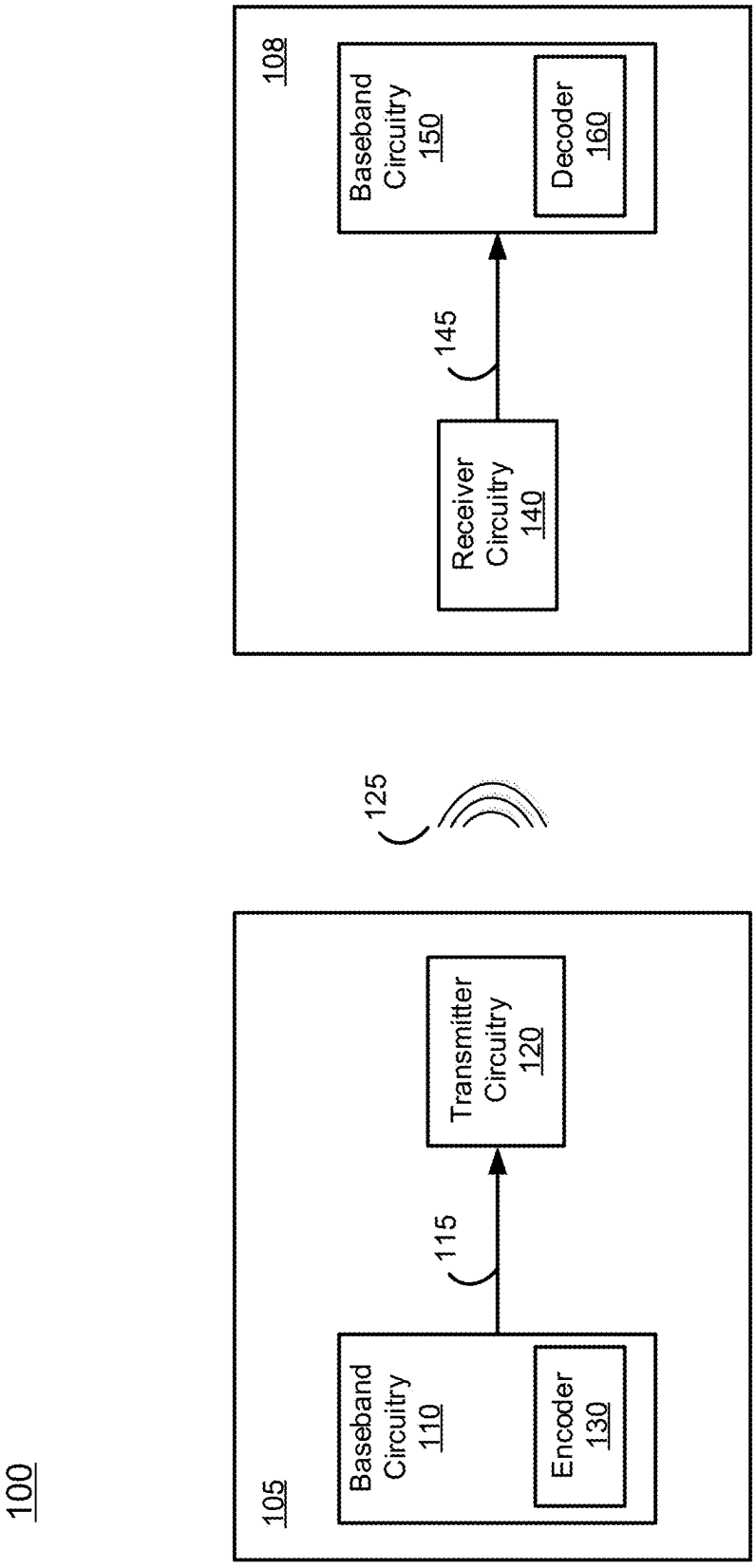

100
105
Baseband Circuitry 110
Encoder 130
115
Transmitter Circuitry 120
125
108
Baseband Circuitry 150
Decoder 160
145
Receiver Circuitry 140

FIG. 1

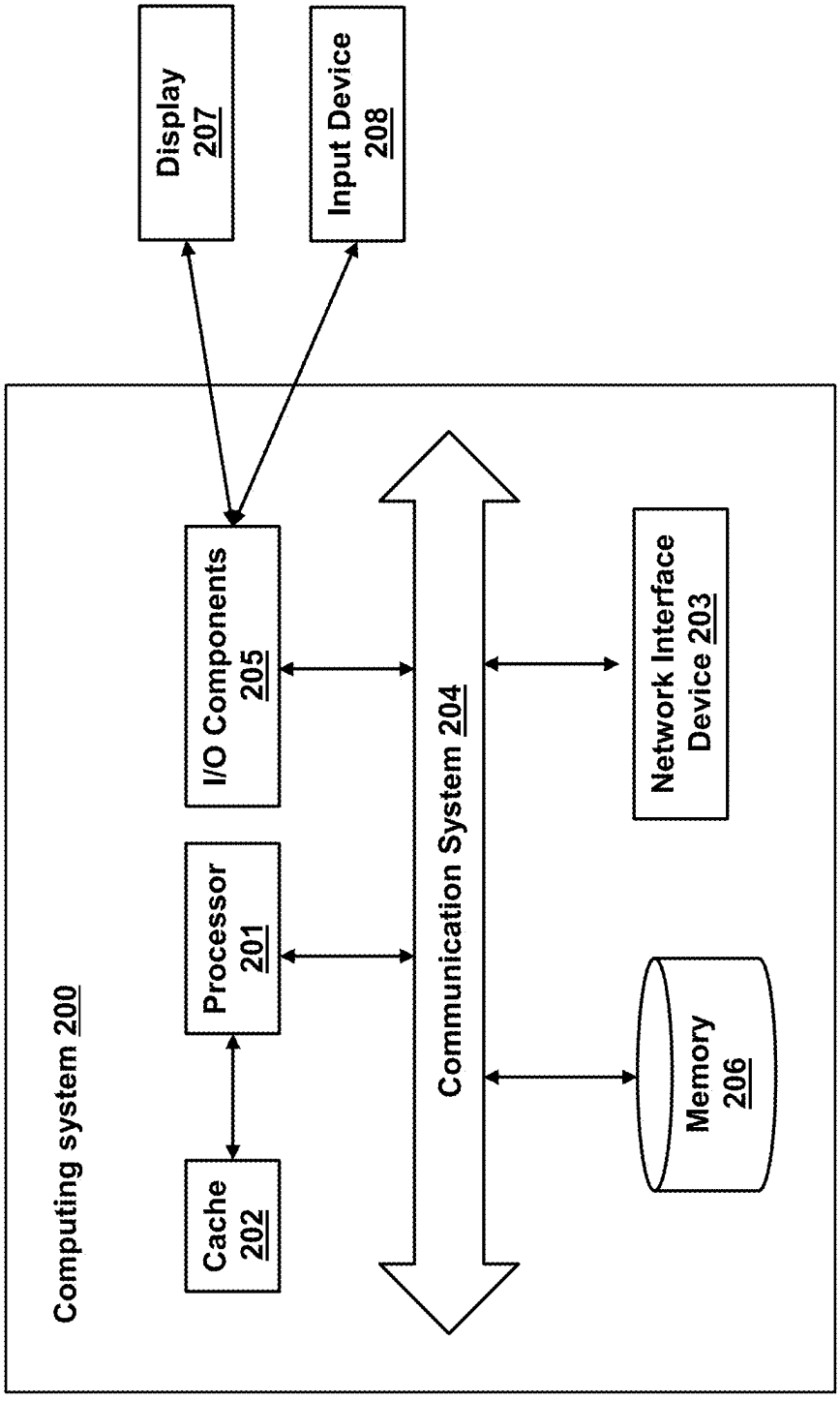

Display 207
Input Device 208
Computing system 200
I/O Components 205
Processor 201
Cache 202
Communication System 204
Network Interface Device 203
Memory 206

FIG. 2

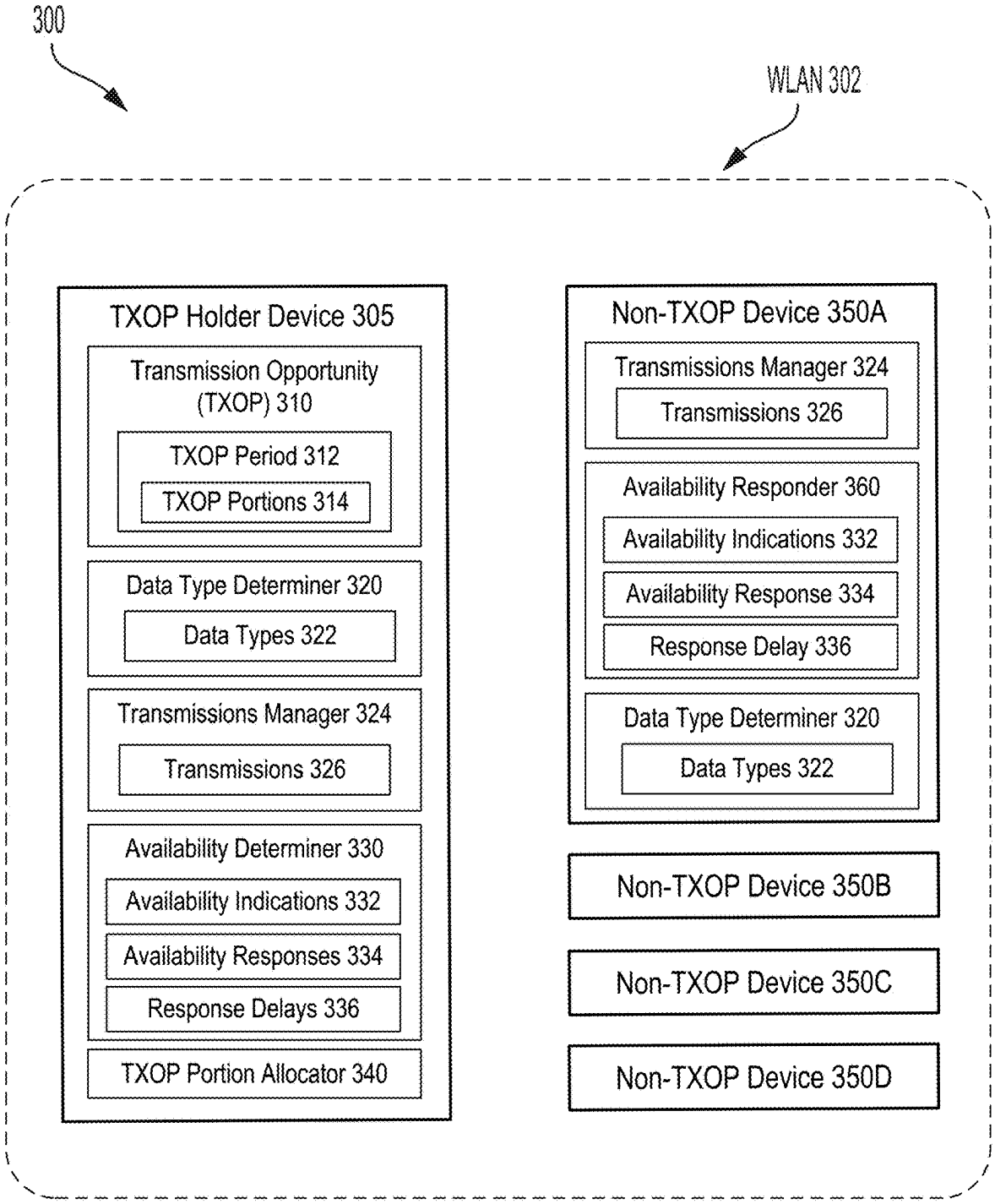

300
WLAN 302
TXOP Holder Device 305
Transmission Opportunity (TXOP) 310
TXOP Period 312
TXOP Portions 314
Data Type Determiner 320
Data Types 322
Transmissions Manager 324
Transmissions 326
Availability Determiner 330
Availability Indications 332
Availability Responses 334
Response Delays 336
TXOP Portion Allocator 340
Non-TXOP Device 350A
Transmissions Manager 324
Transmissions 326
Availability Responder 360
Availability Indications 332
Availability Response 334
Response Delay 336
Data Type Determiner 320
Data Types 322
Non-TXOP Device 350B
Non-TXOP Device 350C
Non-TXOP Device 350D

FIG. 3

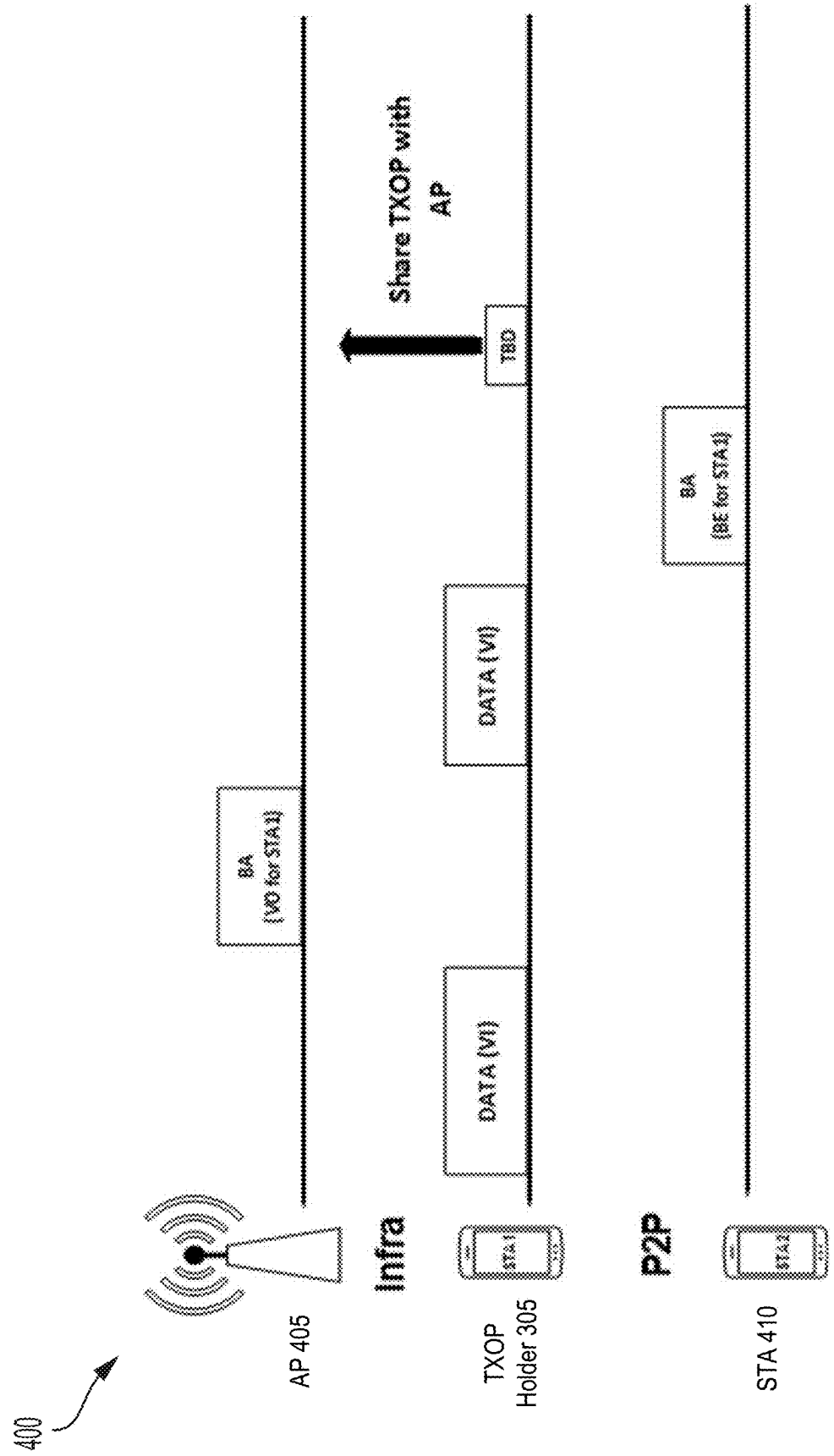

400
AP 405
TXOP Holder 305
STA 410
Infra
P2P
BA (VO for STA 1)
DATA (VI)
DATA (VI)
Share TXOP with AP
TBD
BA (BE for STA 1)

FIG. 4

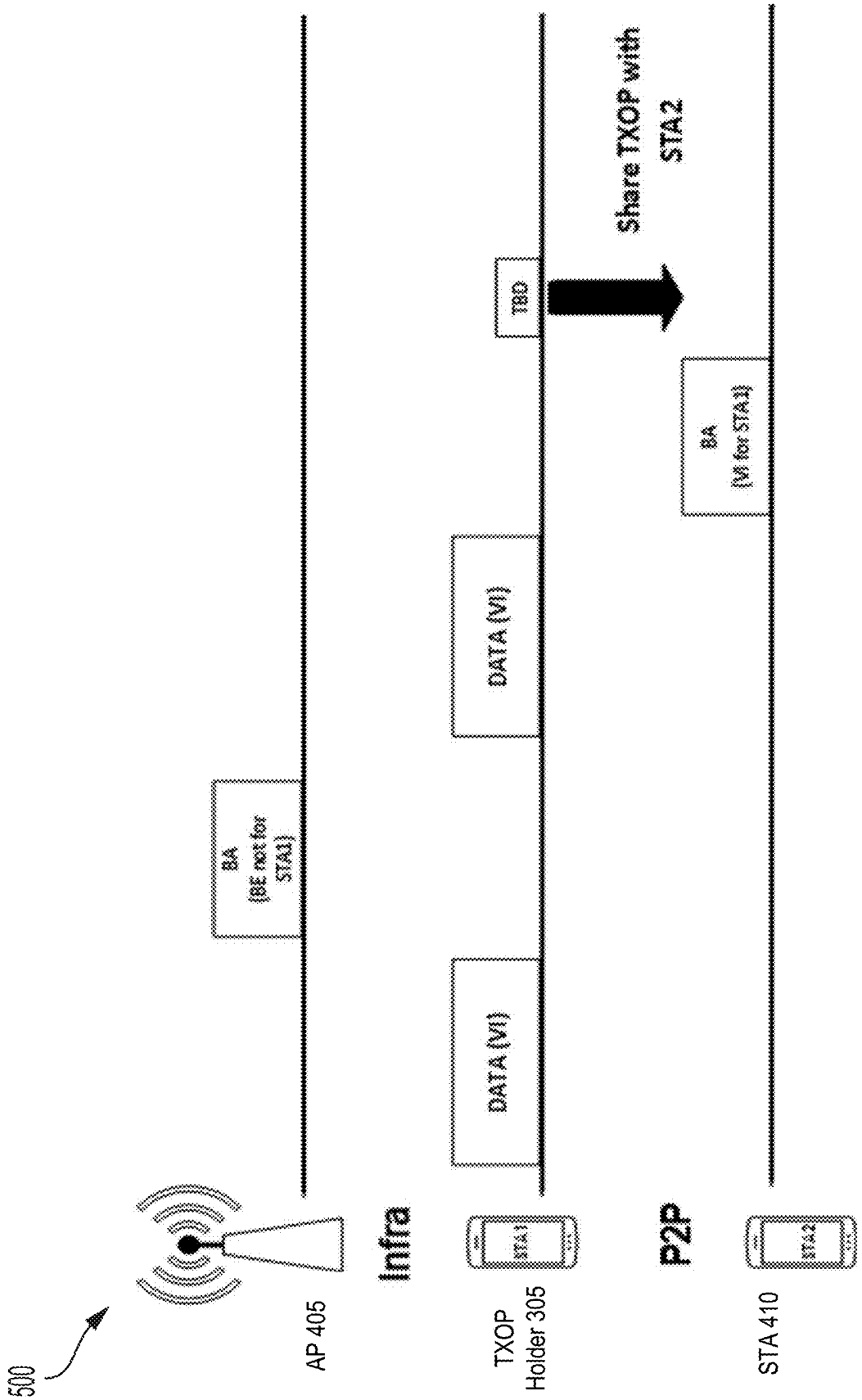

500
AP 405
Infra
TXOP Holder 305
P2P
STA 410
STA 1
STA 2
BA (BE not for STA1)
DATA (VI)
DATA (VI)
TBD
Share TXOP with STA 2
BA (VI for STA1)

FIG. 5

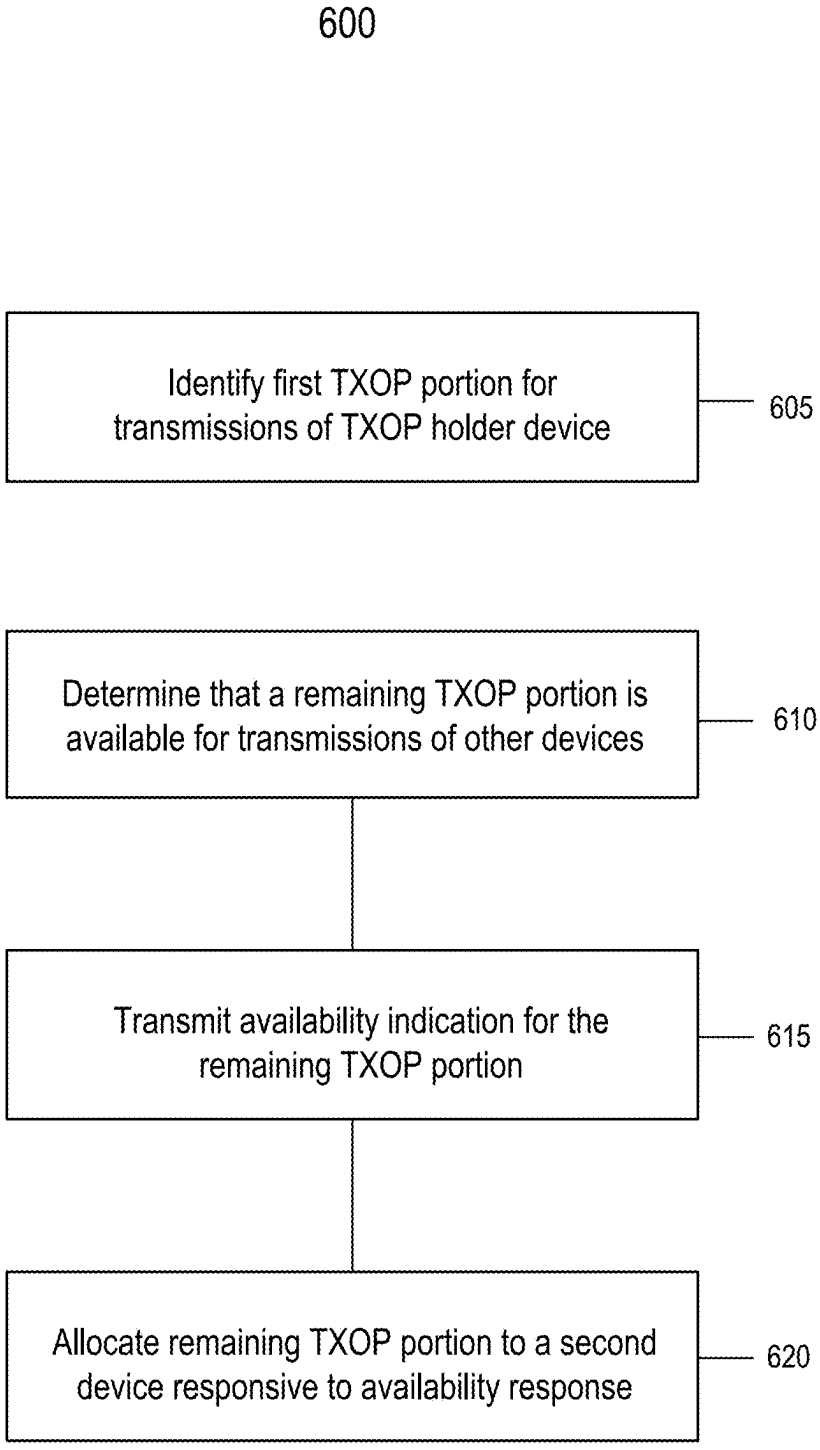

600
Identify first TXOP portion for transmissions of TXOP holder device
605
Determine that a remaining TXOP portion is available for transmissions of other devices
610
Transmit availability indication for the remaining TXOP portion
615
Allocate remaining TXOP portion to a second device responsive to availability response
620

FIG. 6

LATENCY REDUCTION THROUGH CONTROLLER TRANSMIT OPPORUNITY SHARING

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

[0001] This application claims the benefit of and priority to an India Provisional Application No. 20/242,1010608, filed Feb. 15, 2024, and India Provisional Application No. 20/242,1036114, filed May 7, 2024, both of which are incorporated herein by reference in their entirety.

FIELD OF THE DISCLOSURE

[0002] This disclosure generally relates to systems and methods for improving the performance of latency-sensitive traffic through various TXOP sharing mechanisms where the latency-sensitive traffic is allowed to preempt or follow an ongoing frame exchange in a TXOP in a controlled manner.

BACKGROUND

[0003] In wireless communications, time-based scheduling can be used to control transmissions between devices. For instance, a MAC layer feature used in IEEE 802.11-based wireless local area networks (WLANs) can be called a transmission opportunity (TXOP). The amount of time that a station has to send frames after gaining contention for the transmission medium can be defined by TXOP. Other devices on the WLAN may have low latency traffic for transmission.

SUMMARY OF THE DISCLOSURE

[0004] The technical solutions provide systems and methods for transmission opportunity (TXOP) sharing for latency sensitive traffic of non-TXOP holder devices within a TXOP. In various wireless communications, such as for an example wireless local area network (WLAN), a wireless communication device that is granted a TXOP with a particular TXOP period during which the device can transmit their communications can be referred to as a TXOP holder device. During a TXOP granted to a TXOP holder device, non-TXOP devices (e.g., devices in the vicinity which do not hold the TXOP) may have latency sensitive traffic that is to be promptly transmitted, but may be pending for next opportunity. However, as the TXOP is granted to a specific TXOP holder device, it can be challenging for the non-TXOP devices to transmit their latency sensitive traffic during the same TXOP period. The technical solutions of the present disclosure allow for TXOP holder device to share portions of the TXOP period to non-TXOP devices, facilitating transmissions of latency sensitive traffic of the non-TXOP devices during the TXOP granted to the TXOP holder device.

[0005] At least one aspect of the technical solutions is directed to a system. The system can include a first device, such as a device of a wireless local area network (WLAN). The first device can be granted a transmission opportunity (TXOP) for transmissions during a TXOP period. The first device can be configured to identify a first portion of the TXOP period for one or more transmissions of the first device over the WLAN. The first device can be configured to determine that a remaining portion of the TXOP period subsequent to the first portion is available for data transmissions of one or more other devices of the WLAN. The first device can be configured to transmit, via the WLAN, to the one or more other devices, an indication of availability of the remaining portion of the TXOP period for data transmissions. The first device can be configured to allocate, responsive to one or more responses to the indication from the one or more other devices, the remaining portion of the TXOP period to a second device of the one or more other devices to transmit the data of the second device during the portion of the remaining portion of the TXOP period.

[0006] The first device can be configured to schedule a transmission of data of the first device during the first portion of the TXOP period. The first device can be configured to determine, responsive to a determination that the scheduled transmission occupying the first portion of the TXOP period is to be completed prior to a start of the remaining portion, that the remaining portion of the TXOP period is available for the one or more other devices to transmit low latency data during the remaining portion.

[0007] The first device can be configured to determine, based on a response of the one or more responses of the second device, that the data of the second device is low latency data. The first device can be configured to allocate, responsive to the data of the second device being low latency data, the remaining portion to the second device.

[0008] The first device can be configured to identify that a first data of the one or more transmissions of the first device is of a first priority. The first device can be configured to identify that a second data of a second one or more transmissions to be transmitted by the first device is of a second priority lower than the first priority. The first device can be configured to determine, responsive to the second data being of the second priority, to transmit the indication of availability.

[0009] The first device can be further configured to schedule, for the second device, a transmission of the data of the second device that is low latency data, for at least a first part of the remaining portion of the TXOP period. The first device can be further configured to schedule, for a third device of the one or more other devices of the WLAN, a transmission of a data of the third device that is low latency data for at least a second part of the remaining portion of the TXOP period, the second part following the first part.

[0010] The first device can be configured to transmit the indication to the one or more other devices via one or more physical protocol data units (PPDUs). The first device can be configured to receive, from the one or more other devices, one or more block acknowledgements (BAs) responsive to the one or more PPDUs. The one or more BAs can include the one or more responses indicated using one or more bits of one or more fields of the one or more BAs. The first device can be configured to select, based on the one or more bits of the one or more fields of the one or more BAs, the second device.

[0011] The first device can be configured to identify, for a plurality of the one or more other devices, a corresponding plurality of random delays within the TXOP period, each random delay of the plurality of random delays for each device of the one or more other devices different from each other random delay of the plurality of delays of each other device of the one or more other devices.

[0012] The first device can be configured to select, from the one or more other devices, the second device based on a respective random delay of the second device. The first device can be configured to allocate the remaining portion of

the TXOP period to the second device in response to the selection. Each of the plurality of random delays can correspond to a timing for transmitting a respective response of the one or more responses by a respective device of the one or more other devices. The selection of the second device can be based on a respective timing of the random delay of the second device such that the response from the second device is received by the first device before other respective responses of other respective remaining devices.

[0013] The first device can be configured to determine that the second device has completed a transmission of the data of the second device during a first part of the remaining portion of the TXOP period. The first device can be configured to determine to transmit a second one or more transmissions of the first device over the WLAN during a second part of the remaining portion of the TXOP period. The second part can follow the first part. The first device can include a WLAN access point (AP) device and the second device can include a client device associated with the WLAN AP device.

[0014] The first device can include a client device of a WLAN access point (AP) device and the second device can include the WLAN AP device. The first device can be further configured to identify uplink data of the first device to transmit to the second device. The first device can be configured to determine, based on the uplink data, to allocate the remaining portion of the TXOP period to the second device for the second device to transmit downlink data to the first device.

[0015] The first device can be configured to determine to allocate the remaining portion of the TXOP period to the second device based on an amount of the uplink data satisfying a threshold.

[0016] The first device can include a first client device associated with a WLAN access point (AP) device and the second device can include a second client device associated with the WLAN AP device. The first device can be further configured to allocate the remaining portion of the TXOP period to the second device for peer to peer communications.

[0017] An aspect of the technical solutions relates to a method. The method can include identifying, by a first device of a wireless local area network (WLAN) granted a transmission opportunity (TXOP) for transmissions during a TXOP period, a first portion of the TXOP period for one or more transmissions of the first device over the WLAN. The method can include determining, by the first device, that a remaining portion of the TXOP period subsequent to the first portion is available for data transmissions of one or more other devices of the WLAN. The method can include transmitting, by the first device, via the WLAN, to the one or more other devices, an indication of availability of the remaining portion of the TXOP period for data transmissions. The method can include allocating, by the first device, responsive to one or more responses to the indication from the one or more other devices, the remaining portion of the TXOP period to a second device of the one or more other devices to transmit the data of the second device during the portion of the remaining portion of the TXOP period.

[0018] The method can include scheduling, by the first device, a transmission of data of the first device during the first portion of the TXOP period. The method can include determining, by the first device, responsive to a determination that the scheduled transmission occupying the first portion of the TXOP period is to be completed prior to a start of the remaining portion, that the remaining portion of the TXOP period is available for the one or more other devices to transmit low latency data during the remaining portion.

[0019] The method can include determining, by the first device, based on a response of the one or more responses of the second device, that the data of the second device is low latency data. The method can include allocating, by the first device, responsive to the data of the second device being low latency data, the remaining portion to the second device.

[0020] The method can include identifying, by the first device, that a first data of the one or more transmissions of the first device is of a first priority. The method can include identifying, by the first device, that a second data of a second one or more transmissions to be transmitted by the first device is of a second priority lower than the first priority. The method can include determining, by the first device, responsive to the second data being of the second priority, to transmit the indication of availability. The method can include scheduling, for the second device, a transmission of the data of the second device that is low latency data, for at least a first part of the remaining portion of the TXOP period.

[0021] An aspect of the technical solutions relates to a non-transitory computer readable medium. The non-transitory computer-readable medium can store instructions that, when executed by at least one processor of a first device a wireless local area network (WLAN) that is granted a transmission opportunity (TXOP) for transmissions during a TXOP period, can cause the at least one processor to identify a first portion of the TXOP period for one or more transmissions of the first device over the WLAN. The instructions, when executed by the at least one processor, can cause the at least one processor to determine that a remaining portion of the TXOP period subsequent to the first portion is available for data transmissions of one or more other devices of the WLAN. The instructions, when executed by the at least one processor, can cause the at least one processor to transmit, via the WLAN, to the one or more other devices, an indication of availability of the remaining portion of the TXOP period for data transmissions. The instructions, when executed by the at least one processor, can cause the at least one processor to allocate, responsive to one or more responses to the indication from the one or more other devices, the remaining portion of the TXOP period to a second device of the one or more other devices to transmit the data of the second device during the portion of the remaining portion of the TXOP period.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] Various objects, aspects, features, and advantages of the disclosure will become more apparent and better understood by referring to the detailed description taken in conjunction with the accompanying drawings, in which like reference characters identify corresponding elements throughout. In the drawings, like reference numbers generally indicate identical, functionally similar, and/or structurally similar elements.

[0023] FIG. **1** is a diagram depicting an example communication environment with communication systems, according to one or more embodiments.

[0024] FIG. **2** is a schematic block diagram of a computing system, according to an embodiment.

[0025] FIG. **3** is an example of a system for providing a transmission opportunity (TXOP) sharing for latency sensitive traffic of non-TXOP holder devices.

[0026] FIG. **4** is an example in which an access point device, a TXOP holder device and a STA device are engaged in sharing of TXOP.

[0027] FIG. **5** is an example in which an AP, a TXOP holder device and a STA are engaged in sharing of TXOP.

[0028] FIG. **6** is an example method of providing a TXOP sharing for latency sensitive traffic of non-TXOP holder devices within a TXOP granted to a TXOP holder device.

[0029] The details of various embodiments of the methods and systems are set forth in the accompanying drawings and the description below.

DETAILED DESCRIPTION

[0030] The following IEEE standard(s), including any draft versions of such standard(s), are hereby incorporated herein by reference in their entirety and are made part of the present disclosure for all purposes: Wi-Fi Alliance standards and IEEE 802.11 standards including but not limited to IEEE 802.11a™, IEEE 802.11b™, IEEE 802.11g™, IEEE P802.11n™; IEEE P802.11ac™; and IEEE P802.11be™ draft version D3.0 standards. Although this disclosure can reference aspects of these standard(s), the disclosure is in no way limited by these standard(s).

[0031] The following disclosure provides many different embodiments, or examples, for implementing different features of the provided subject matter. Specific examples of components and arrangements are described below to simplify the present disclosure. These are, of course, merely examples and are not intended to be limiting. For example, a first feature or a device in communication with or communicatively coupled to a second feature or a device in the description that follows may include embodiments in which the first feature is in direct communication with or directly coupled to the second feature and may also include embodiments in which additional features may intervene between the first and second features, such that the first feature is in indirect communication with or indirectly coupled to the second feature. In addition, the present disclosure may repeat reference numerals and/or letters in the various examples. This repetition is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed.

[0032] Various embodiments disclosed herein are related to one or more apparatuses, devices and/or systems, including a transmitter and/or receiver and one or more processors and that may be configured, constructed or implemented to communicate using any encoding process and techniques as defined or supported by any IEEE 801.11 standard such as 902.11n, 802.11AC, 802.11ax and 802.11be or other versions and embodiments of the IEEE 802.11 standard.

[0033] TXOP (Transmission Opportunity) can refer to a time interval during which a device in a wireless network may be granted the right or ability to transmit data without contention (e.g., without competing with other devices for access to the network). TXOP can be gained through an Enhanced Distributed Channel Access [EDCA] mechanism. The technical solutions allow preemption of an ongoing frame exchange of a TXOP holder device (e.g., a device that is granted the TXOP) with low latency traffic of other (e.g., non-TXOP holding) devices on a wireless network, such as a WLAN, Bluetooth, Cellular Networks, Zigbee, Mesh Networking or others. The technical solutions can utilize a mechanism in a Wi-Fi system (e.g., 11bn) for a TXOP holder device (e.g., a Wi-Fi AP or a STA) to allow a STA that is associated with the TXOP holder and that is not granted the TXOP, to preempt the TXOP holder's frame exchange sequence in favor of a delivery of low latency traffic by the STA (e.g., the non-TXOP holder device). In such instances, the TXOP holder device can utilize one portion of the TXOP for its own transmissions, while allowing the non-TXOP holder to use the remaining (e.g., other) portions of the TXOP, for the transmissions by the non-TXOP holder STA. One or more policies may be set or determined for the TXOP holder to allow for such a preemption mechanism.

[0034] The technical solutions allow a preemption by the TXOP holder device through inserting a point coordination function (PCF) interframe space (PIFS) gap ahead of its preemptible transmission. In doing so, the technical solutions allow for low-latency traffic to be transmitted by the preempting device using a SIFS (Shortest Interface spacing) gap. Upon detecting this transmission after SIFS gap, the TXOP holder can aborts its intended transmission.

[0035] The technical solutions allow transmission of low latency traffic by a device within the TXOP acquired by, or granted to, another device (e.g., a TXOP holder). The technical solutions can consider various factors, such as whether the TXOP holder is an AP or a non-AP, whether the TXOP holder has more traffic (even of low priority) to send (or additionally in case of an AP, to schedule) in its current TXOP, whether the low latency transmission is to be allowed from only the TXOP responder(s) or even other device(s) in the basic service set (BSS).

[0036] Based on such considerations, embodiments of the technical solutions can utilize approaches that can be categorized into two categories, such as when the TXOP holder device is an AP, and when the TXOP holder device is not an AP (e.g., a STA). The technical solutions can be used to share medium access even across technologies such as UWB (Ultra-wide band) or high priority Bluetooth to preempt an ongoing transaction provided by the Wi-Fi TXOP. For Wi-Fi embodiments and standards, low latency traffic can be a target and the proposed solutions can achieve this target with minimal or minimized product complexity.

[0037] Advantages of the technical solution is to achieve low latency service by allowing TXOP sharing in a regulated manner so as to minimize collisions and also minimize product complexity. The technical solutions can be provided for dynamically allocated opportunities based on indicated requirements and can have the benefit or advantage of being compliant with applicable regional regulations, such as EU regulations.

[0038] Referring to FIG. **1**, illustrated is a diagram depicting an example communication environment **100** including communication systems (or communication apparatuses) **105**, **108**, according to one or more embodiments. In one embodiment, the communication system **105** includes a baseband circuitry **110** and a transmitter circuitry **120**, and the communication system **108** includes a baseband circuitry **150** and a receiver circuitry **140**. In one aspect, the communication system **105** is considered a transmitter communication system, and the communication system **108** is considered a receiver communication system. These components operate together to exchange data (e.g., messages or frames) through a wireless medium. These components are embodied as application specific integrated circuit (ASIC), field programmable gate array (FPGA), or any combination of these, in one or more embodiments. In some embodiments, the communication systems **105**, **108** include more,

fewer, or different components than shown in FIG. **1**. For example, each of the communication systems **105**, **108** includes transceiver circuitry to allow bi-directional communication between the communication systems **105**, **108** or with other communication systems. In some embodiments, each of the communication systems **105**, **108** may have configuration similar to that of a computing system **200** as shown in FIG. **2**.

[0039] The baseband circuitry **110** of the communication system **105** is a circuitry that generates the baseband data **115** for transmission. The baseband data **115** includes information data (e.g., signal(s)) at a baseband frequency for transmission. In one approach, the baseband circuitry **110** includes an encoder **130** that encodes the data and generates or outputs parity bits. In one aspect, the baseband circuitry **110** (or encoder **130**) obtains a generator matrix or a parity check matrix or uses a previously produced generator matrix or a previously produced parity check matrix and encodes the information data by applying the information data to the generator matrix or the parity check matrix to obtain a codeword. In some embodiments, the baseband circuitry **110** stores one or more generator matrices or one or more parity check matrices that conform to any IEEE 802.11 standard for WLAN communication. The baseband circuitry **110** retrieves the stored generator matrix or the stored parity check matrix in response to detecting information data to be transmitted, or in response to receiving an instruction to encode the information data. In one approach, the baseband circuitry **110** generates the parity bits according to a portion of the generator matrix or using the parity check matrix and appends the parity bits to the information bits to form a codeword. The baseband circuitry **110** generates the baseband data **115** including the codeword for the communication system **108** and provides the baseband data **115** to the transmitter circuitry **120**.

[0040] The transmitter circuitry **120** of the communication system **105** includes or corresponds to a circuitry that receives the baseband data **115** from the baseband circuitry **110** and transmits a wireless signal **125** according to the baseband data **115**. In one configuration, the transmitter circuitry **120** is coupled between the baseband circuitry **110** and an antenna (not shown). In this configuration, the transmitter circuitry **120** up-converts the baseband data **115** from the baseband circuitry **110** onto a carrier signal to generate the wireless signal **125** at an RF frequency (e.g., 10 MHz to 60 GHz), and transmits the wireless signal **125** through the antenna.

[0041] The receiver circuitry **140** of the communication system **108** is a circuitry that receives the wireless signal **125** from the communication system **105** and obtains baseband data **145** from the received wireless signal **125**. In one configuration, the receiver circuitry **140** is coupled between the baseband circuitry **150** and an antenna (not shown). In this configuration, the receiver circuitry **140** receives the wireless signal **125** though an antenna, and down-converts the wireless signal **125** at an RF frequency according to a carrier signal to obtain the baseband data **145** from the wireless signal **125**. The receiver circuitry **140** then provides the baseband data **145** to the baseband circuitry **150**.

[0042] The baseband circuitry **150** of the communication system **108** includes or corresponds to a circuitry that receives the baseband data **145** from the receiver circuitry **140** and obtains information data from the received baseband data **145**. In one embodiment, the baseband circuitry **150** includes a decoder **160** that extracts information and parity bits from the baseband data **145**. The decoder **160** decodes the baseband data **145** to obtain the information data generated by the baseband circuitry **110** of the communication system **105**.

[0043] In some embodiments, each of the baseband circuitry **110** (including the encoder **130**), the transmitter circuitry **120**, the receiver circuitry **140**, and the baseband circuitry **150** (including the decoder **160**) may be as one or more processors, application specific integrated circuit (ASIC), field programmable gate array (FPGA), or any combination of them.

[0044] FIG. **2** is a schematic block diagram of a computing system **200**, according to an embodiment. An illustrated example computing system **200**, also referred to as a computer system **200**, can include one or more processors **201** in direct or indirect communication, via a communication system **204** (e.g., bus), with memory **206**, at least one network interface controller **203** with network interface port for connection to a network (not shown), and other components, e.g., input/output ("I/O") components **205**. Generally, the processor(s) **201** can execute instructions (e.g., computer code or programs) received from memory (e.g., **206** or **202**). The processor(s) **201** illustrated can incorporate, or are connected to, cache memory **202**. In some instances, instructions are read from memory **206** into cache memory **202** and executed by the processor(s) **201** from cache memory **202**. The computing system **200** may not necessarily contain all of these components shown in FIG. **2** and may contain other components that are not shown in FIG. **2**.

[0045] In more detail, the processor(s) **201** may be any logic circuitry that processes instructions, e.g., instructions fetched from the memory **206** or cache **202**. In many implementations, the processor(s) **201** are microprocessor units or special purpose processors. The computing device **205** may be based on any processor, or set of processors, capable of operating as described herein. The processor(s) **201** may be single core or multi-core processor(s). The processor(s) **201** may be multiple distinct processors.

[0046] The memory **206** may be any device suitable for storing computer readable data. The memory **206** may be a device with fixed storage or a device for reading removable storage media. Examples include all forms of volatile memory (e.g., RAM), non-volatile memory, media and memory devices, semiconductor memory devices (e.g., EPROM, EEPROM, SDRAM, and flash memory devices), magnetic disks, magneto optical disks, and optical discs (e.g., CD ROM, DVD-ROM, or Blu-Ray® discs). A computing system **200** may have any number of memory devices **206**.

[0047] The cache memory **202** is generally a form of computer memory placed in close proximity to the processor (s) **201** for fast read times. In some implementations, the cache memory **202** is part of, or on the same chip as, the processor(s) **201**. In some implementations, there are multiple levels of cache **202**, e.g., L2 and L3 cache layers.

[0048] The network interface controller **203** manages data exchanges via the network interface (sometimes referred to as network interface ports). The network interface controller **203** handles the physical and data link layers of the OSI model for network communication. In some implementations, some of the network interface controller's tasks are handled by one or more of the processor(s) **201**. In some implementations, the network interface controller **203** is part

of a processor **201**. In some implementations, the computing system **200** has multiple network interfaces **203** controlled by a single controller. In some implementations, the computing system **200** has multiple network interface controllers **203**. In some implementations, each network interface is a connection point for a physical network link (e.g., a cat-5 Ethernet link). In some implementations, the network interface controller **203** supports wireless network connections and an interface port is a wireless (e.g., radio) receiver or transmitter (e.g., for any of the IEEE 802.11 protocols, near field communication "NFC", Bluetooth, ANT, or any other wireless protocol). In some implementations, the network interface controller **203** implements one or more network protocols such as Ethernet. Generally, a computing device **205** exchanges data with other computing devices via physical or wireless links through a network interface. The network interface may link directly to another device or to another device via an intermediary device, e.g., a network device such as a hub, a bridge, a switch, or a router, connecting the computing device **200** to a data network such as the Internet.

[0049] The computing system **200** may include, or provide interfaces for, one or more input or output ("I/O") devices. Input devices include, without limitation, keyboards, microphones, touch screens, foot pedals, sensors, MIDI devices, and pointing devices such as a mouse or trackball. Output devices include, without limitation, video displays, speakers, refreshable Braille terminal, lights, MIDI devices, and 2-D or 3-D printers.

[0050] Other components may include an I/O interface, external serial device ports, and any additional co-processors. For example, a computing system **200** may include an interface (e.g., a universal serial bus (USB) interface) for connecting input devices, output devices, or additional memory devices (e.g., portable flash drive or external media drive). In some implementations, a computing device **200** includes an additional device such as a co-processor, e.g., a math co-processor can assist the processor **201** with high precision or complex calculations.

[0051] The components **209** may be configured to connect with external media, a display **207**, an input device **208** or any other components in the computing system **200**, or combinations thereof. The display **207** may be a liquid crystal display (LCD), an organic light emitting diode (OLED) display, a flat panel display, a solid state display, a cathode ray tube (CRT) display, a projector, a printer or other now known or later developed display device for outputting determined information. The display **207** may act as an interface for the user to see the functioning of the processor (s) **201**, or specifically as an interface with the software stored in the memory **206**.

[0052] The input device **208** may be configured to allow a user to interact with any of the components of the computing system **200**. The input device **208** may be a plurality pad, a keyboard, a cursor control device, such as a mouse, or a joystick. Also, the input device **208** may be a remote control, touchscreen display (which may be a combination of the display **207** and the input device **208**), or any other device operative to interact with the computing system **200**, such as any device operative to act as an interface between a user and the computing system **200**.

[0053] FIG. **3** illustrates an example system **300** for providing a transmission opportunity (TXOP) sharing for latency sensitive traffic of non-TXOP holder devices. System **300** can incorporate, utilize or be implemented using any combination of features of a communication environment **100** of FIG. **1** or a computing system **200** of FIG. **2**. System **300** can include a TXOP holder device **305** and one or more non-TXOP devices **350** (e.g., devices **350**A, **350**B, **350**C or **350**D) that can communicate with each other via a wireless network, such as a wireless local area network (WLAN) **302**, or any other wireless network or technology, such as for example, Bluetooth, Zigbee, cellular network or a Mesh network. TXOP holder device **305** can include one or more of transmission opportunities (TXOPs) **310**, that can include one or more of transmission opportunity (TXOP) periods **312**. Each TXOP period **312** can include any number (e.g., plurality) of transmission opportunity (TXOP) portions **314**. A TXOP portion **314** can include a time duration, subsection or a portion of time within the TXOP **310**, during which one or more transmissions (e.g., by the TXOP holder device **305** or by one or more other non-TXOP devices **350**) can be implemented (e.g., transmitted across the WLAN).

[0054] TXOP holder device **305** can include one or more data type determiners **320** for determining various data types **322** that can be transmitted. TXOP holder device **305** can include one or more transmission managers **324** for managing or implementing various transmissions **326**. TXOP holder device **305** can include one or more TXOP portion allocators **340** for allocating various TXOP portions **314** to different WLAN devices (e.g., TXOP holder device **305** or any of non-TXOP devices **350** (e.g., **350**A-D). TXOP holder device **305** can include one or more availability determiners **330** for generating, processing or providing availability indications **332** and receiving or processing availability responses **334** from various non-TXOP devices **350** along with, or according to, any response delays **336** of such availability responses **334**.

[0055] The non-TXOP devices **350** (e.g., **350**A-D) can each include one or more transmission managers **324** for managing the transmissions **326** of the non-TXOP device **350**, and one or more data type determiners **320** for determining the data types **322** of the non-TXOP device **350**. The non-TXOP devices **350** can include one or more availability responders **360** that can receive one or more availability indications **332** (e.g., from the TXOP holder device **305**) and generate (e.g., responsive to such availability indications **332**) one or more availability responses **334**, along with response delays **336** for such availability responses **334** of the non-TXOP devices **350**. Depending on dynamic changing or granting of TXOP **310**, which can be granted or assigned to any of the devices, the TXOP holder **305** can turn into non-TXOP device **350** and vice versa, depending on the implementation.

[0056] A TXOP holder device **305** can be device of WLAN **302** that is granted a transmission opportunity (TXOP) **310** to use for transmissions (e.g., transmissions from the TXOP holder device **305**) during a TXOP period **312** of the TXOP **310**. The TXOP holder device **305** can include a WLAN access point (AP) device, or a client device (e.g., a STA) associated with the WLAN AP device. The TXOP **310** can be granted to the TXOP holder device **305** by a WLAN access point (AP) or by another TXOP holder device **305** (e.g., station). The TXOP holder device **305** can identify a first TXOP portion **314** of the TXOP period **312** for one or more transmissions of the TXOP holder device **305** over the WLAN **302**. The first TXOP portion **314** of the TXOP can be an initial portion of the TXOP **310** during

which the TXOP holder device **305** can transmit the network traffic of the TXOP holder device **305**. The TXOP holder device **305** can utilize the availability determiner **330** to identify, detect or determine that a remaining TXOP portion **314** of the TXOP period **312**, that is subsequent to the first TXOP portion **314**, is available for data transmissions of one or more other (e.g., non-TXOP) devices **350** of the WLAN **302**.

[0057] The TXOP holder device **305** can include a client device (e.g., a STA) of a WLAN access point (AP) device and the non-TXOP device **350** can include a WLAN AP device. The TXOP holder device **305** can identify uplink data of the first device (e.g., **305**) to transmit to the second device (e.g., **350**). The TXOP holder device **305** can determine, based on the uplink data, to allocate the remaining portion of the TXOP period **312** (e.g., the remaining TXOP portion **314**) to the second device (e.g., **350**) for the second device to transmit downlink data to the first device (e.g., **305**). The remaining TXOP portion **314** can include any portion of the TXOP **310** granted to the TXOP holder device **305**, during which the non-TXOP devices **350** can transmit their network traffic, following the first TXOP portion **314**. The first device (e.g., **305**) can be configured to determine to allocate the remaining portion of the TXOP period **312** to the second device (e.g., **350**) based on an amount of the uplink data satisfying a threshold. For instance, the threshold can include an amount of uplink data that is satisfied (e.g., exceeded) by the uplink data. The TXOP holder device **305** can include a first client device associated with a WLAN access point (AP) device and the second device can include a second client device associated with the WLAN AP device, where the first device can allocate the remaining portion (e.g., **314**) of the TXOP period **312** to the second device for peer to peer communications.

[0058] The TXOP holder device **305** can utilize the availability determiner **330** to generate and transmit, via the WLAN **302**, to the one or more other (e.g., non-TXOP) devices **350**, an indication of availability (e.g., the availability indication **332**). The indication of availability (e.g., **332**) can include any indication, message or transmission that can indicate to the non-TXOP devices **350** availability of the remaining TXOP portion **314** of the TXOP **310** for transmissions of the non-TXOP devices **350**. For instance, in response to determining that low latency transmissions are completed, or about to be completed, the TXOP holder device **305** can determine to generate availability indication **332** to the non-TXOP devices **350** on the WLAN **302** to check if any of the non-TXOP devices **350** have low-latency transmissions to transmit via the WLAN **302**, during a remaining TXOP portion **314** of the TXOP **310**.

[0059] The TXOP holder device **305** can receive, in response to the availability indication **332** transmitted by the TXOP holder device **305** to the one or more other devices, one or more availability responses **334** to the availability indication **332**. The TXOP holder device **305** can utilize a TXOP portion allocator **340** to determine, select or allocate, responsive to the received one or more availability responses **334**, the remaining portion (e.g., **314**) of the TXOP period **312** to a second device (e.g., a non-TXOP device **350**) of the one or more other (e.g., non-TXOP) devices. The second device can use the remaining TXOP portion **314** to transmit the data of the second device during at least a part of the remaining portion of the TXOP period **312**.

[0060] Wireless local area network (WLAN) **302** can include any network allowing devices (e.g., **305** or **350**) to connect and communicate wirelessly within a limited area, using for example Wi-Fi technology. WLAN **302** can include any implementation of a Wireless Local Area Network that allows communication between multiple network devices within a localized area, such as a home, office, or campus. WLAN **302** can facilitate the exchange of data among devices, including TXOP holder device **305** and non-TXOP devices **350**, by using wireless transmission methods, such as those conforming to standards including IEEE 802.11. WLAN **302** can allow these devices to connect and share transmission opportunities (TXOPs) and manage data transmissions through a structured and controlled environment. WLAN **302** can support various types of data communication, including voice, video, and best-effort traffic, depending on the needs and configurations of the communicating devices. The wireless nature of WLAN **302** can provide flexibility and mobility to the devices, allowing such devices (e.g., **305** or **350**) to communicate without the constraints of physical cables.

[0061] Transmission opportunity (TXOP) holder device **305** can include any combination of hardware and software (e.g., a network device) that has acquired, or has been granted, a TXOP **310** to control or transmit data over a network during a specified TXOP period. The TXOP holder device **305** can include any device configured for communication via a wireless local area network (WLAN) **302** that has gained control over transmission opportunities (TXOPs). The TXOP holder device **305** can be responsible for managing and allocating TXOP periods **312** to itself or other devices within the WLAN **302**. The TXOP holder device **305** can facilitate or orchestrate communications and allow for efficient use of the available TXOP periods **312**. For instance, a TXOP holder device **305** can include a Wi-Fi access point (AP) device or a client (e.g., smartphone, tablet or a computer) wireless communication device that can acquire a TXOP **310** for managing network traffic over one or more TXOP periods **312** or over one or more TXOP portions **314** of a TXOP period **312**.

[0062] Non-TXOP device **350** can include any device within a WLAN **302** that does not currently hold a TXOP **310** but can receive transmissions and respond to availability indications **332** for possible low-latency transmissions during the TXOP period **312**. The non-TXOP devices **350** (e.g., devices **350**A, **350**B, **350**C, or **350**D) can include devices within the WLAN **302** that do not initially hold the TXOP **310**. The non-TXOP devices **350** can communicate with the TXOP holder device **305** and with each other. The non-TXOP devices **350** can rely on the TXOP holder device **305** to allocate portions of the TXOP period **312** (e.g., one or more TXOP portions **314**) to be used for transmissions by the non-TXOP devices **350**. Non-TXOP devices **350** can include various client devices such as smartphones, laptops, or IoT devices that can participate in network communications under the coordination of the TXOP holder device **305**.

[0063] Transmission opportunity (TXOP) **310** can represent one or more specific time intervals during which the TXOP holder device **305** can transmit data over the WLAN **302**. The TXOP **310** can be used for ordering communications to avoid communication collisions and managing network traffic. TXOP **310** can allow the TXOP holder to control the flow of information within the specified time intervals. TXOPs **310** can allow the TXOP holder device

305 to have the exclusive access to the wireless medium, reducing collisions and optimizing network performance, as well as allowing other non-TXOP devices **350**, to transmit data.

[0064] Transmission opportunity (TXOP) periods **312** can include any time-interval subdivisions within the TXOP **310**. TXOP periods **312** can provide one or more TXOP **310** subdivisions during which a particular network device (e.g., TXOP holder device **305** or non-TXOP device **350**) can transmit or receive data. Each TXOP period **312** can include a defined time slot that can be further divided into multiple portions (e.g., TXOP portions **314**) that can be used or dedicated for different types of transmissions. TXOP periods **312** can be utilized for synchronizing or timing of data transmissions within the WLAN **302**, allowing that each device has sufficient time to send its data.

[0065] Transmission opportunity (TXOP) portions **314** can include any portions or segments within a TXOP period **312**. TXOP portions **314** can be allocated by the TXOP holder device **305** for specific transmissions, such as transmissions of a particular data type **322** or transmissions by a particular device (e.g., **305** or **350**). TXOP portions **314** allow for partial or granular allocation of sections of TXOP period **312** to different devices or types of data (e.g., low latency transmissions or high priority transmissions), allowing for improved or optimized use of available bandwidth. For example, a TXOP portion **314** can be allocated for video data transmission, while another portion can be reserved for voice or best-effort traffic.

[0066] Data type determiner **320** can include any combination of hardware or software within a device (e.g., TXOP holder device **305** or the non-TXOP device **350**) that can identify and categorize the types of data. Data type determiner **320** can include the functionality to detect, identify or detect any types of data to be transmitted over the WLAN **302**. Data type determiner **320** can identify or distinguish low latency data from other data that can tolerate longer delays. Data type determiner **320** can assess the nature of the data-such as video, voice, or best-effort traffic—and help prioritize transmissions based on data type. Such categorization can be utilized to facilitate that latency-sensitive data, such as video data, is transmitted promptly, while other data (e.g., audio) can be transmitted with some higher delay.

[0067] Data types **322** can include any type and form of data that can be transmitted over WLAN **302**. Data types **322** can include different categories of data that can be transmitted by the TXOP holder device **305** or the non-TXOP devices **350**. Data types **322** can include different priority levels of data, such as high priority data (e.g., augmented reality data, control signals, gaming data or video streaming) and low priority data (e.g., internet of things routine updates, background sync of collaborative work data) that can tolerate higher threshold delays. Data types **322** can include video (VI), voice (VO), best-effort (BE) traffic, gaming data, sensor data, control signals, financial transactions, emergency notifications, virtual reality or augmented reality data, IoT data, or collaborative work data. Data types **322** can include high priority or low latency data of various types (e.g., control signals, gaming data, video streaming).

[0068] Transmissions manager **324** can include any combination of hardware and software for managing the execution of transmissions **326** by either TXOP holder device **305** or the non-TXOP devices **350**. Transmissions manager **324** can oversee the scheduling, initiation, and completion of data transmissions, such as transmission of low latency data, high latency data or any transmissions communicated via WLAN **302**. Transmissions manager **324** can include the functionality to allow each device to transmit its data efficiently within its allocated TXOP portion. For example, a transmission manager **324** can schedule a video data transmission during a high-priority TXOP portion while deferring less critical data transmissions to later transmissions.

[0069] The transmissions manager **324** can schedule a transmission **326** of data of the first device during the first portion of the TXOP period **312** (e.g., a first TXOP portion **314**). The first portion of the TXOP period **312** (e.g., a first TXOP portion **314**) can be assigned by the transmissions manager **324** to a non-TXOP device **350**, to be taken back or reclaimed by the TXOP holder device **305** during a second portion **314** that follows the first portion. For instance, a TXOP holder can determine that the data to be transmitted by the TXOP holder is old, should be refreshed or can be updated and may therefore take more time before the TXOP holder **305** is ready to transmit its own data. In response to such a determination, the TXOP holder **305** can assign, grant or schedule for a second device a first TXOP portion **314** and schedule a second TXOP portion **314** following the first TXOP portion **314** for the TXOP holder **305** once the updated or refreshed data has arrived and is ready for transmission.

[0070] The first device (e.g., TXOP holder device **305**) can be configured to schedule, for a second device (e.g., non-TXOP device **350**), a transmission **326** of the data of the second device that is low latency data, for at least a first part of the remaining portion of the TXOP period. For instance, the first device (e.g., TXOP holder device **305**) can be configured to schedule, for a third device (e.g., another non-TXOP device **350**) of the one or more other devices of the WLAN **302**, a transmission **326** of a data of the third device that is low latency data for at least a second part (e.g., **314**) of the remaining portion of the TXOP period **312**. The second part (e.g., the second TXOP portion **314**) of the TXOP period **312** can follow the first part of the TXOP period (e.g., the first TXOP portion **314**).

[0071] Transmissions **326** can include any act of transmitting or sending data over the WLAN **302** by either the TXOP holder device **305** or the non-TXOP devices **350**. Transmissions **326** can occur during allocated TXOP portions **314** of a TXOP period **312**. Transmissions **326** can be managed by the transmission managers **324**. Transmissions **326** can vary in nature depending on the data types **322**, with each type utilizing specific handling for efficient and timely delivery.

[0072] Availability determiner **330** can include any combination of hardware and software for a TXOP holder device **305** to determine, detect or identify availability for non-TXOP devices **350** to utilize one or more TXOP portions **314** for transmissions of their communications (e.g., low latency or high priority communications). Availability determiner **330** can identify or detect TXOP portions **314** within a TXOP period **312** to provide to non-TXOP devices **350** for transmissions of their network traffic (e.g., low latency or high priority transmissions).

[0073] Availability determiner **330** can generate, process or provide availability indications **332** to the non-TXOP devices **350**. Availability determiner **330** can handle the reception and processing of availability responses **334** (e.g., generated by non-TXOP devices **350** responsive to the

availability indications **332**). Availability determiner **330** can take into account any response delays **336**. The availability determiner **330** plays a key role in coordinating the use of the remaining TXOP period by assessing which devices are ready to transmit and how much time is available.

[0074] Availability determiner **330** can determine that a remaining portion (e.g., upcoming TXOP portion **314**) of the TXOP period **312** is available for the one or more other (e.g., non-TXOP) devices **350** to transmit low latency data during the remaining portion. For instance, the availability determiner **330** can determine that the remaining TXOP portion **314** is available for transmissions **326** by one or more non-TXOP devices **350** responsive to a determination that the scheduled transmission **326** occupying the first portion of the TXOP period **312** is to be completed prior to a start of the remaining portion (e.g., **314**).

[0075] Availability determiner **330** can determine, based on a response of the one or more availability responses **334** of the second device (e.g., non-TXOP device **350**), the data type **322** of the transmission **326**. For instance, the availability determiner **330** can determiner, based on an availability response **334**, that the data of the second device is high priority data or low latency data. The availability determiner **330** can identify that a first data of the one or more transmissions of the first device is of a first priority. The availability determiner **330** can identify that a second data of a second one or more transmissions to be transmitted by the first device is of a second priority lower than the first priority and determine, responsive to the second data being of the second priority, to transmit the availability indication **332**.

[0076] Availability determiner **330** can transmit the availability indication **332** to the one or more other (e.g., non-TXOP) devices **350** via one or more physical protocol data units (PPDUs). The availability determiner **330** can receive, from the one or more other devices (e.g., non-TXOP devices **350**), one or more block acknowledgements (BAs) responsive to the one or more PPDUs. The one or more BAs can include the one or more responses (e.g., availability responses **334**) that can be indicated using one or more bits of one or more fields of the one or more BAs. For instance, a non-TXOP device **350** can indicate that it has transmissions **326** of low latency type to transmit in the TXOP portions **314** made available by the TXOP holder device **305** using bits in the fields of the BA. The availability determiner **330** can select, based on the one or more bits of the one or more fields of the one or more BAs, the second device (e.g., non-TXOP device **350**) for transmissions during the remaining TXOP portion **314**.

[0077] Availability determiner **330** can identify, for a plurality of the one or more other (e.g., non-TXOP) devices **350**, a corresponding plurality of random response delays **336** within the TXOP period **312**. Each random response delay **336** of the plurality of random delays for each device of the one or more other (e.g., non-TXOP) devices **350** can be different from each other random response delay **336** of the plurality of delays of each other non-TXOP device **350** of the one or more other devices. The random response delays **336** can each identify the non-TXOP device **350** associated with the given response delay **336**.

[0078] The availability determiner **330** can select, from the one or more other devices (e.g., **350**), the second device (e.g., a non-TXOP device **350** to use for transmissions **326** via TXOP portions **314**) based on a respective random delay (e.g., response delay **336**) of the second device. For instance, the availability determiner **330** of the TXOP holder device **305** can select from a plurality of non-TXOP devices **350**, a particular non-TXOP device **350** to grant TXOP portion **314** for transmissions. This selection can be made based on the response delay **336** of the particular non-TXOP device **350**. For instance, the availability determiner **330** can select a particular non-TXOP device **350** based on response delay **336** of this non-TXOP device **350** being the shortest response delay **336** of the plurality of response delays **336** for which the availability response **334** indicated that low latency data is to be transmitted. The TXOP portion allocator **340** can then, responsive to the selection by the availability determiner **330**, allocate the remaining portion of the TXOP period **312** to the second device (e.g., the selected non-TXOP device **350**) in response to the selection.

[0079] Each of the plurality of random delays **336** (e.g., of each of the plurality of availability responses **334**) can correspond to a timing for transmitting a respective availability response **334** of the one or more responses by a respective non-TXOP device **350** of the one or more other non-TXOP devices **350**. The selection of the second device (e.g., non-TXOP device **350** to utilize the remainder of the TXOP portions **314**) can be based on a respective timing of the random response delay **336** (e.g., of the availability response **334**) of the second device such that the availability response **334** from the second device is received by the first device (e.g., TXOP holder device **305**) before other respective responses of other respective remaining devices.

[0080] The availability determiner **330** can determine that the second device (e.g., non-TXOP device **350** to be selected for transmissions via TXOP portions **314**) has completed a transmission **326** of the data of the second device during a first part of the remaining portion of the TXOP period **312**. The availability determiner **330** can determine to transmit a second one or more transmissions of the first device over the WLAN **302** during a second part of the remaining portion of the TXOP period **312**. The second part of the remaining portion TXOP period **312** can follow the first part.

[0081] Availability indications **332** can include any signals or messages sent by the TXOP holder device **305** to inform the non-TXOP devices **350** that a remaining TXOP portion **314** of the TXOP period **312** is available for transmissions by non-TXOP devices **350**. Availability indication **332** can be transmitted by the TXOP holder device **305** to indicate to the non-TXOP devices **350** that low latency transmissions by the non-TXOP devices **350** can be transmitted during one or more upcoming TXOP portions **314**. Availability indication **332** can be used for coordinating the transmissions by non-TXOP devices **350** during a remaining TXOP period (e.g., TXOP portion **314** that remains available for non-TXOP device **350** transmissions within the TXOP **310**). Availability indication **332** transmitted by a TXOP holder device **305** can allow non-TXOP devices **350** to respond and potentially gain access (e.g., the remaining TXOP portion **314**) for their wireless transmissions.

[0082] Availability responses **334** can include any responses or replies by the non-TXOP devices **350**, responsive to receiving availability indications **332** from the TXOP holder device **305**. Availability responses **334** can indicate whether the non-TXOP devices are ready to use the remaining TXOP period for low latency transmissions. Availability responses **334** can be generated according to particular

device-specific delays (e.g., response delays **336**) to avoid collisions with other responding devices. The TXOP holder device **305** can use availability responses **334** from the non-TXOP devices **350** to determine or decide how to allocate the remaining TXOP period (e.g., TXOP portion **314**) effectively to other non-TXOP devices **350**.

[0083] Response delays **336** can include any timing delays associated with the availability responses **334** sent by the non-TXOP devices **350**. Each non-TXOP device **350** can have a unique response delay **336** for transmitting its availability responses **334** to availability indications **332** of the TXOP holder device **305**. The response delays **336** can correspond to a unique time duration between the availability indication **332** transmission or a receipt and a time of transmitting the availability response **334** of the non-TXOP device **350**. For instance, a first non-TXOP device **350** can have a first response delay **336** for sending its first availability response **334** to an availability indication **332** of a TXOP holder device **305**. For instance, a second non-TXOP device **350** can have a second response delay **336** (e.g., different than the first response delay **336** of the first non-TXOP device **350**) for sending its second availability response **334** to the same availability indication **332**. Based on the differences in time durations of the two response delays **336**, one of the availability responses **334** can be transmitted before the second, avoiding collisions and also providing a prioritization of some of the non-TXOP devices **350** over others. Response delays **336** can impact how quickly the TXOP holder device **305** receives and processes the availability responses, which in turn can affect the scheduling of transmissions within the remaining TXOP period **312**. Availability determiner **330** can manage the response delays **336** to facilitate allocating the remaining transmission time (e.g., assigning TXOP portions **314** to particular non-TXOP devices **350**).

[0084] TXOP portion allocator **340** can include any combination of hardware and software for distributing the TXOP portions **314** among various WLAN devices, including both the TXOP holder device itself and any non-TXOP devices **350** (e.g., **350**A-D). TXOP portion allocator **340** can facilitate that each device receives an appropriate share of the TXOP period based on factors such as data type, priority, and device capabilities. TXOP portion allocator **340** can include the functionality to determine identify the non-TXOP devices **350** that has data for transmissions that is of highest priority (e.g., low latency data), thereby prioritizing those non-TXOP device transmissions that are of higher priority than others. The TXOP portion allocator **340** can allocate, responsive to the data of the second device (e.g., non-TXOP device **350**) being low latency data, the remaining TXOP portion **314** to the second device (e.g., for transmissions during the one or more TXOP portions **314**).

[0085] Availability responder **360** can include any combination of hardware and software within the non-TXOP devices **350** that can receive availability indications **332** (e.g., from the TXOP holder device **305**) and generate availability responses **334**. Availability responder **360** can generate the availability response **334** for a non-TXOP device **350** based on a response delay **336** that is unique to that non-TXOP device **350**. Availability responders **360** of multiple non-TXOP devices **350** can generate unique response delays **336** for the availability responses **334**, allowing each of the availability response **334** to be transmitted at a unique delay window from the availability indication **332**. Availability responder **360** can indicate whether the non-TXOP devices are prepared to use the remaining portion of the TXOP period **312** (e.g., TXOP portion **314**) for transmissions (e.g., low latency transmissions).

[0086] The technical solutions can be directed to enhancing the performance of latency-sensitive traffic through various TXOP sharing mechanisms in which the latency-sensitive traffic is allowed to preempt or follow an ongoing frame exchange in a TXOP in a controlled manner. The TXOP holder devices can be Wi-Fi AP devices or non-AP devices (e.g., STAs). The TXOP holder can have traffic to send, including of higher or lower priority than that of non-TXOP devices. The low latency transmissions can be allowed from the TXOP responders or from other devices in the BSS.

[0087] When an AP is the TXOP holder device **305** and the AP has no more data to send or schedule in its TXOP **310** and wants to share the remaining portion of the TXOP **312**, the TXOP holder can utilize one or more solutions to share portions of the TXOP with non-TXOP devices. For instance, the device can utilize TXOP sharing (TXS) modes 1 and 2 defined in 11be. These schemes however can have the restriction that the AP can share its TXOP with only 1 client. Such sharing can be based on information received from the client regarding possible UL or P2P transmissions, but without any accurate estimate of the amount of traffic. This may not allow the AP to share the remainder of the TXOP in a non-dedicated manner (i.e. when the identity of the potential transmitter of the low latency (LL) traffic is not known at the AP).

[0088] The AP can schedule an LL traffic indication and subsequently schedule LL traffic based on response(s) to the LL traffic indication. For TXOP responder(s), LL traffic indication can be implemented by overloading reserved bits in the BA or by using the QoS control or buffer status report (BSR) control subfields in the same PPDU as BA. For non-TXOP responders, a scheme similar to uplink orthogonal random access (UORA) can be used, where the AP indicates a latency-sensitive group AID allowing all clients with latency sensitive TIDs to compete and based on a probability, win access to the UORA resources and indicate only the presence of LL traffic. Following such indication of LL traffic from its clients, the AP can trigger the clients with LL traffic in a dedicated manner.

[0089] As an optimization, the clients may use orthogonal codes (which may be defined) to transmit their respective LL traffic indications on the same resource. The AP (e.g., TXOP holder) can schedules LL traffic directly. For instance, the AP can a scheme similar to UORA, in which the AP indicates a latency-sensitive group AID allowing all clients with latency sensitive TIDs to compete randomly and transmit such traffic in the remainder of the TXOP. Such transmission of LL traffic by the clients can be single user (SU) or multi-user (MU), or resource unit (RU) resolution without any dedicated scheduling by the AP.

[0090] The SU option can have the advantage that it allows the AP to take back ownership of the TXOP (by PIFS based recovery) in case the client cannot utilize all of the remaining TXOP. In this case, the AP can reallocate the TXOP for the same purpose or use it for any new arrived latency-sensitive traffic. The MU option can utilize the AP to specify a common duration and for the clients to pad their LL transmissions up to the common duration, in order to

avoid misaligned transmissions. The non-TXOP device can indicate presence of LL traffic either for the AP or for its peer and the AP's sharing of resources can be in accordance with that. The AP can use PIFS based recovery of its TXOP for any of the above schemes if the clients do not have sufficient LL traffic to utilize (e.g., fully or partially) the TXOP shared by the AP.

[0091] In one configuration, the AP can be configured as the TXOP holder device **305** and the AP has more data to send or schedule in its TXOP. However, the TXOP holder can determine that it is ok to pause to allow latency-sensitive traffic from other clients in its BSS. The AP when it schedules MU-BA, can also include dedicated allocation for LL traffic indication in a UORA manner so that subsequently, it can cede the TXOP. The AP can cede the TXOP by scheduling those specific clients which indicated the presence of LL traffic. The AP can cede the TXOP by indicating that it is going to pause transmission in this TXOP so that potential transmitters of LL traffic take over after SIFS gap. The AP can use this option when it receives LL traffic indication from a small number of clients as the probability of collision may be low. The client can indicate presence of LL traffic either for the AP or for its peer and the AP's sharing of resources can be in accordance with that.

[0092] In some configurations, TXOP holder device **305** can include non-AP devices, such as STAs. In such configurations, a client device can be unable to receive DL data due to hidden nodes and may either have no more UL data to send or may not intend to transmit any more UL data in the TXOP. The client may be unable to receive DL data as the AP may not have knowledge of the activity durations of a hidden node which prevent the client from responding with clear to send (CTS) or acknowledgement (ACK). The client may be aware of this hidden node activity. The client can acquire TXOP and hand it to the AP to transmit DL data to it.

[0093] In some configurations, the client may have no more UL data to send in the TXOP and may determine to share the remainder of the TXOP. The client can indicate that it has finished transmitting along with the access category of gaining the TXOP and the remaining duration in the TXOP. How to utilize the remainder can be determined by the AP or client policy. For instance, the remainder can be used only for transmissions to the particular client who shared the TXOP. For instance, the remainder can be used for latency-sensitive and control traffic to other clients. For example, the remainder can be used for any traffic with priority equal to or higher than the indicated access category (AC) but up to a threshold duration.

[0094] In some configurations of the non-AP TXOP holder, the client may have no more data to send in the TXOP but can pause to allow latency-sensitive traffic from other devices in the BSS. Similar to the case where the AP is the TXOP holder, the client can allow an opportunity for LL traffic indication from the AP or even from other clients in the BSS. The LL traffic indication transmission by any of those devices can be based on a random probability such that whoever wins, transmits the LL indication. The opportunity for non-TXOP responders can be as an RU in frequency division multiplexing (FDM) with the BA sent by the AP or as a time slot immediately after BA. The LL traffic indication sought from the TXOP responder(s) can be implemented by overloading the reserved bits in the BA. Based on it, the client can pause its transmission. For instance, other devices can take over based on a random probability. For example, the AP can take over and schedule other clients. The AP may not have detected the other clients which transmitted LL traffic indication during its own BA transmission. So, the client which relinquishes its TXOP can include this information while doing so.

[0095] In some configurations, the non-AP device that is configured as TXOP holder can include the client having P2P traffic to send and wanting to utilize the remaining TXOP for that instead of ceding it for LL transmission by the AP or other in-BSS devices. In this case, the client can send an indication to the AP that it will be using the remaining TXOP for P2P exchange. This approach can be more efficient than here a client may need to send PM=1 to its AP, start a fresh EDCA process to win the channel and then communicate over the P2P link.

[0096] In some configuration, low latency traffic indication can be done in various ways. For instance, a general LL indication can include a bit of a transmission (e.g., of a BA) to indicate the presence/absence of LL traffic. In some scenarios, the LL traffic may be not associated with a correspondingly high access priority class such as AC_VO or AC_VI. However, the LL traffic indication can specify the access priority class(s) of the traffic that can use such a shared TXOP. In case random resources are allocated, the identity of the device with LL traffic can also utilize a part of the indication. The LL traffic can be intended for the TXOP holder or for another client or peer.

[0097] The traffic can be marked as low latency in various ways. As enhanced schemes to improve the performance of latency-sensitive traffic get defined, this may also warrant appropriate marking of traffic as latency sensitive. For the purpose of some techniques, the traffic can be appropriately marked as latency-sensitive before it utilizes these schemes. The user priority and access category of flows may be not concordant with the latency requirement of the traffic. The voice packets may use user priority resulting AC_BE and it is also possible for rogue applications/users to mark low priority best effort traffic as AC_VO. The SCS parameters and the QoS characteristics element values can be used to determine the latency tolerance and flow rate of a flow and accordingly mark it as latency-sensitive irrespective of the user priority or access category.

[0098] FIG. **4** illustrates an example **400** in which an access point (AP) **405** a TXOP holder device **305** and a STA (e.g., client or station device) **410** are engaged in sharing of TXOP **310**. Example **400** illustrates a sequence of communication events in a WLAN **302** involving an Access Point (AP) **405**, a TXOP holder device **305** (e.g., first station, STA1) and a second STA **410** (e.g., a second station, a P2P device). The timeline for each device shows the TXOP holder device **305** initially transmitting data labeled "Data (VI)" (e.g., video data) on its line, followed by the AP **405** responding with a Block Acknowledgment "BA (VO for STA1)" (e.g., voice data for STA 1 or TXOP holder device **305**) on its line. TXOP holder device **305** can then transmit another "Data (VI)" frame (e.g., video data), after which STA **410** (e.g., STA2) can respond with a block acknowledgement "BA (BE for STA1)" indicating a best effort traffic category for STA1. Finally, STA1's timeline shows a "TBD" event with an arrow to the AP's line, indicating that STA1 shares the remaining TXOP with the AP. This sequence demonstrates how STA1, as the TXOP holder, manages data

transmissions and coordinates with the AP and STA2 to optimize the use of the transmission opportunity.

[0099] Technical solutions can include allowing the TXOP holder to decide whether to explicitly share the TXOP. TXOP sharing can be enabled between AP and non-AP STAs in both directions, as well as between IBSS STAs and P2P STAs. To facilitate this, a mechanism can be provided for STAs to indicate their interest in acquiring the shared TXOP, potentially by embedding information in Block-ACK frames.

[0100] TXOP sharing in UHR can be enhanced by embedding information in Block-ACK to help the TXOP holder make more informed sharing decisions. Proposed information in Block-ACK could include, potentially using reserved bits of the BA Control field, details such as the highest priority AC pending for transmission and whether the traffic is intended for the STA receiving the BA or for another STA.

[0101] FIG. **5** illustrates an example **500** in which an access point (AP) **405** a TXOP holder device **305** and a STA (e.g., client or station device) **410** are engaged in sharing of TXOP **310**. Example **500** represents a sequence of data transmissions and acknowledgments involving three devices: an AP **405**, a TXOP holder device **305** and a STA **410**. Each device has its timeline, illustrating the sequence of communication events. The first event occurs on TXOP holder device **305** (e.g., STA1) timeline, where it transmits "Data (VI)"—indicating a video transmission. Following this, on the AP **405** timeline, there is a box labeled "BA (BE not for STA1)," indicating that the AP **405** sends a Block Acknowledgment (BA) for Best Effort (BE) traffic, not intended for STA1. The next event on TXOP holder **305** (e.g., STA1) timeline is another "Data (VI)" transmission, showing a continuation of video data transmission. Following this, STA2 can respond with "BA (VI for STA1)," acknowledging the video data (VI) received from STA1. Finally, on STA1's timeline, there is a box labeled "TBD," with an arrow pointing downward to STA2's timeline, indicating that STA1 is sharing its Transmission Opportunity (TXOP) with STA2, allowing the AP to communicate with STA2 within the same TXOP period.

[0102] Some configurations can include a scheme that can utilize the benefits of Defer Signal (DS) based distributed access enhancements. The TXOP holder, which can be a UHR AP or a UHR non-AP, can transmit at the end of its frame exchange in a TXOP, a special trigger frame to allow the transmissions by owners of LL traffic within a special contention period immediately following (e.g., after SIFS from) the special trigger. A UHR non-AP may be able to transmit this special trigger frame provided it is authorized by its UHR AP to do so. The special trigger frame can identify which owners of LL traffic are allowed to transmit in the special contention period following the special trigger: e.g., by limiting to in-BSS devices, by allowing OBSS devices, by advertising one of different predetermined groups of devices as being allowed.

[0103] In some cases, the above special trigger frame may be transmitted by an AP after a short gap G=SIFS+N*slots from the end of an UL TXOP that was initiated by a non-AP (the non-AP could be UHR or pre-UHR/legacy from within its BSS). In such instances, N could be pre-determined (zero or non-zero) or chosen such that N<=N_MAX where N_MAX could be pre-determined. The choice can be pre-determined either in the standard, or as a configuration parameter for the network (which may be advertised to all devices).

[0104] The technical solutions can include improvements to distributed access. For instance, this special trigger frame can explicitly reserve the medium for the special contention period, by setting NAV, for SIFS+x (e.g., one or more) slots from the end of the trigger frame. If the special trigger frame reserves x slots, candidate LL traffic owners can count down a random number K between 0 and x−1 and transmit the LL packet directly SIFS+K*slots, without needing to transmit the DS.

[0105] In some configurations, the special trigger frame may not reserve the medium for any additional duration, and candidate LL traffic owners transmit DS (using this trigger frame for alignment) either SIFS or PIFS after the end of trigger frame. The special trigger frame may serve the purpose of time and frequency alignment including the corrections to various frequency offsets for the transmission of DS. This can alleviate the concern that the DS may not be otherwise detected properly by other devices. The DS can be a CTS2SELF message with a pre-determined duration value (e.g., EIFS). Following the transmission of the DS i.e. from the end of it, devices which have transmitted DS can count down for a random number of slots (e.g., between 0 to 7) and transmit the LL packet.

[0106] FIG. **6** illustrates an example method **600** of providing a transmission opportunity (TXOP) sharing for latency sensitive traffic of non-TXOP holder devices within a TXOP granted to a TXOP holder device. Method **600** can be implemented, using for example, systems **100-300** of FIGS. **1-3**, or any of the features discussed in connection with FIGS. **1-5**. Method **600** can include acts **605-620**. At **605**, the method can include identifying a first TXOP portion for transmissions of TXOP holder device. At **610**, the method can include determining that a remaining TXOP portion is available for transmissions of other devices. At **615**, the method can include transmitting availability indication for the remaining TXOP portion. At **620**, the method can include allocating remaining TXOP portion to a second device responsive to the availability response.

[0107] At **605**, the method can include identifying a first transmission opportunity (TXOP) portion for transmissions of a TXOP holder device. The method can include a first device (e.g., a TXOP holder device), configured to identify a first portion of a TXOP period, for one or more transmissions of the first device transmitted, or to be transmitted, over a wireless local area network (WLAN). The first device can be a TXOP holder network device of the WLAN that is granted a TXOP for sending transmissions to other (e.g., non-TXOP devices) over the WLAN, during the designated, assigned or granted TXOP period (e.g., time period of the TXOP).

[0108] In some implementations, the first device can determine to assign, grant or schedule the first portion of the TXOP period to another (e.g., a second device). The first device can determine that the first device does not include data ready for immediate transmission within the first portion of the TXOP period. For instance, the first device can identify that the data to be transmitted by the first device is old, stale or is to be refreshed. The first device can determine that the first portion of the TXOP period is to be not fully utilized by the first device given the data of the first device for transmission. In response to such a determination, the

first device can assign the first portion of the TXOP holder to a second device, assigning, granting or scheduling the second portion that follows the first portion of the TXOP period, to the first device for transmissions of the first device.

[0109] The first device can be a TXOP holder device and can include a WLAN access point (AP) device, such as a Wi-Fi router. The first device can communicate to other (e.g., non-TXOP devices), such as a second device, which can include a station (e.g., STA) or any other client device (e.g., a smartphone, tablet or computer device in communication with the WLAN AP). The second device can be associated with, or in wireless communication with, the TXOP holder device (e.g., WLAN AP device or the first device). In some implementations, the first device can be or include a STA or a client device (e.g., a smartphone, tablet or a computer) that is a TXOP holder device and that is communicatively coupled with a second device, which can be or include a WLAN AP device (e.g., Wi-Fi router device), which is a non-TXOP device.

[0110] The first device (e.g., the TXOP holder device) can schedule communication. For instance, the first device can schedule a transmission of data of the first device during the first portion of the TXOP period. The TXOP holder device can schedule one or more transmissions from the first device to one or more non-TXOP devices over the course of one or more TXOP portions of one or more TXOP periods. The TXOP holder device can schedule and execute one or more transmissions from the TXOP holder device or to the TXOP holder device, over the course of the TXOP that is granted to the TXOP holder device. The one or more transmissions can be implemented responsive to the TXOP holder device prioritizing low latency transmissions (e.g., high priority data) over other data. The one or more transmissions can be low latency or high priority data or transmissions.

[0111] At **610**, the method can determine that a remaining TXOP portion is available for transmissions of other devices. For example, the method can include determining that a remaining portion of the TXOP period subsequent to the first portion (e.g., in which the TXOP holder device transmitted its own transmissions) is available for data transmissions of one or more other devices of the WLAN. The one or more other devices can be the non-TXOP holder devices of the WLAN, such as other Wi-Fi APs, STAs or clients on the WLAN that are not designed TXOP holder devices for the given TXOP. The remaining portion of the TXOP period can include one or more TXOP portions which can be used for one or more transmissions by the non-TXOP devices.

[0112] The method can include determining, responsive to a determination that the scheduled transmission occupying the first portion of the TXOP period is to be completed prior to a start of the remaining portion, that the remaining portion of the TXOP period is available for the one or more other devices to transmit low latency data during the remaining portion. The method can include the TXOP holder device identifying that a first data of the one or more transmissions of the first device is of a first priority. The TXOP holder device can identify that a second data of a second one or more transmissions to be transmitted by the first device is of a second priority lower than the first priority. The TXOP holder device can determine, responsive to the second data being of the second priority, to transmit the indication of availability.

[0113] At **615**, the method can include transmitting availability indication for the remaining TXOP portion. The method can include the TXOP holder device transmitting, via the WLAN, to the one or more other devices (e.g., non-TXOP device), one or more indications of availability of the remaining portion of the TXOP period for data transmissions. The TXOP holder device can determine that low latency transmissions of the TXOP holder device are completed during the first portion of the TXOP period and that the remaining portion of the TXOP period (e.g., following the first portion) can be used for low latency transmissions by non-TXOP devices. In response to such a determination, the TXOP holder device can transmit one or more availability indications to notify the non-TXOP devices that the remainder of the TXOP period will be available for high priority or low latency traffic of the non-TXOP devices.

[0114] The method can include transmitting the indication of availability to the one or more other (e.g., non-TXOP) devices via one or more physical protocol data units (PPDUs). The indication can include, for example, one or more data bits within one or more fields of the PPDUs used to indicate the availability indication. The TXOP holder device can receive, from the one or more other devices, one or more block acknowledgements (BAs) responsive to the one or more PPDUs. The one or more BAs can include one or more availability responses from the one or more non-TXOP devices. The one or more responses can indicate whether the non-TOP devices are to participate in the TXOP portion made available by the TXOP holder device. The one or more responses can be indicated using one or more bits of one or more fields of the one or more BAs. Upon receiving the one or more BAs (e.g., availability responses) responsive to the one or more PPDUs (e.g., availability indication), the TXOP holder device can select, based on the one or more bits of the one or more fields of the one or more BAs, the second device. The second device can be the non-TXOP device that will transmit its data (e.g., low latency traffic) via the TXOP portions made available by the TXOP holder device.

[0115] The method can include identifying, for a plurality of the one or more other devices, a corresponding plurality of random delays within the TXOP period. Each random delay of the plurality of random delays for each device of the one or more other (e.g., non-TXOP) devices can be different from each other random delay of the plurality of delays of each other device of the one or more other devices. For instance, a first non-TXOP device can respond to the availability indication of the TXOP holder device with a first availability response having a first response delay of a first time period delay length, while a second non-TXOP device can respond to the same availability indication with a second availability response having a second response delay of a second time period delay length that is different (e.g., longer or shorter) than the first time period length. The length of the time period delay can be unique to each non-TXOP device and can be randomly assigned to each of the device on the WLAN.

[0116] The TXOP holder device can select from the one or more other (e.g., non-TXOP) devices, the particular second device whose transmissions will be transmitted during the remaining TXOP portions, based on a respective random delay of the second device. For instance, the TXOP holder device can select a particular non-TXOP device, based on a plurality of response delays of a plurality availability

responses from the plurality of non-TXOP devices. The particular non-TXOP device can be selected based on the availability response identifying the non-TXOP device indicating having low latency traffic to send during the TXOP portion. The availability response identifying the low-latency traffic from the particular non-TOXP device can be received before other availability responses are received by the TXOP holder device. For instance, the second device can be selected based on the response delay of the availability response of the second device being the earliest affirmative response received responsive to the availability indication.

[0117] The TXOP holder device can allocate the remaining portion of the TXOP period to the second device in response to the selection. Each of the plurality of random delays can correspond to a timing for transmitting a respective response of the one or more responses by a respective device of the one or more other devices. The selection of the second device can be based on a respective timing of the random delay of the second device such that the response from the second device is received by the first device before other respective responses of other respective remaining devices.

[0118] At **620**, the method can include allocating remaining TXOP portion to a second device responsive to the availability response. The method can include allocating, responsive to one or more responses to the indication from the one or more other devices, the remaining portion of the TXOP period to a second device of the one or more other devices to transmit data of the second device during the remaining portion of the TXOP period. The TXOP holder device can receive the one or more availability responses to the availability indication and can identify, from the plurality or responses, those responses that indicate presence of low latency traffic that can be transmitted by the non-TXOP devices. The TXOP holder device can select from the identified responses indicating the low latency traffic, those responses that have arrived first, or those that have the largest amount of low latency traffic to transmit.

[0119] The TXOP holder device can select, from the one or more other devices, the second device based on a respective random delay of the second device. The TXOP holder device can allocate the remaining portion of the TXOP period to the second device in response to the selection. The TXOP holder device can select, from the one or more other devices, the second device based on the amount of low latency or high priority network traffic indicated by the response to be transmitted by the non-TXOP device.

[0120] The TXOP holder device can determine, based on a response of the one or more responses of the second device, that the data of the second device is low latency data. The TXOP holder device can allocate, responsive to the data of the second device being low latency data, the remaining portion to the second device. The first device (e.g., the TXOP holder device) can be configured to schedule, for the second device, a transmission of the data of the second device that is low latency data. Such a transmission can be scheduled for at least a first part of the remaining portion of the TXOP period. The first device can be configured to schedule, for a third device of the one or more other devices of the WLAN, a transmission of a data of the third device that is low latency data for at least a second part of the remaining portion of the TXOP period. The second part of the TXOP period can be a TXOP portion that is following the first part of the TXOP period during which the second device transmitted its low latency traffic.

[0121] The TXOP holder device can determine that the second device has completed a transmission of the data of the second device during a first part of the remaining portion of the TXOP period. The TXOP holder device can determine to transmit a second one or more transmissions of the first device over the WLAN during a second part of the remaining portion of the TXOP period, the second part following the first part. The TXOP holder device can identify uplink data of the first device to transmit to the second device and determine, based on the uplink data, to allocate the remaining portion of the TXOP period to the second device for the second device to transmit downlink data to the first device. The first device can be configured to determine to allocate the remaining portion of the TXOP period to the second device based on an amount of the uplink data satisfying a threshold. The threshold can be a threshold amount of uplink data. The first device can include a first client device associated with a WLAN access point (AP) device and the second device can include a second client device associated with the WLAN AP device. The first device can be configured to allocate the remaining portion of the TXOP period to the second device for peer to peer communications (e.g., Bluetooth communications).

[0122] References to "or" may be construed as inclusive so that any terms described using "or" may indicate any of a single, more than one, and all of the described terms. References to at least one of a conjunctive list of terms may be construed as an inclusive OR to indicate any of a single, more than one, and all of the described terms. For example, a reference to "at least one of 'A' and 'B'" can include only 'A', only 'B', as well as both 'A' and 'B'. Such references used in conjunction with "comprising" or other open terminology can include additional items.

[0123] It should be noted that certain passages of this disclosure can reference terms such as "first" and "second" in connection with subsets of transmit spatial streams, sounding frames, response, and devices, for purposes of identifying or differentiating one from another or from others. These terms are not intended to merely relate entities (e.g., a first device and a second device) temporally or according to a sequence, although in some cases, these entities can include such a relationship. Nor do these terms limit the number of possible entities (e.g., STAs, APs) that can operate within a system or environment. It should be understood that the systems described above can provide multiple ones of any or each of those components and these components can be provided on either a standalone machine or, in some embodiments, on multiple machines in a distributed system. Further still, bit field positions can be changed, and multibit words can be used. In addition, the systems and methods described above can be provided as one or more computer-readable programs or executable instructions embodied on or in one or more articles of manufacture, e.g., a floppy disk, a hard disk, a CD-ROM, a flash memory card, a PROM, a RAM, a ROM, or a magnetic tape. The programs can be implemented in any programming language, such as LISP, PERL, C, C++, C#, or in any byte code language such as JAVA. The software programs or executable instructions can be stored on or in one or more articles of manufacture as object code.

[0124] While the foregoing written description of the methods and systems enables one of ordinary skill to make

and use embodiments thereof, those of ordinary skill will understand and appreciate the existence of variations, combinations, and equivalents of the specific embodiment, method, and examples herein. The present methods and systems should therefore not be limited by the above described embodiments, methods, and examples, but by all embodiments and methods within the scope and spirit of the disclosure.

What is claimed is:

1. A system comprising:

a first device of a wireless network granted a transmission opportunity (TXOP) for transmissions during a TXOP period, the first device configured to:

identify a first portion of the TXOP period for one or more transmissions of the first device over the wireless network;

determine that a remaining portion of the TXOP period subsequent to the first portion is available for data transmissions of one or more other devices of the wireless network;

transmit, via the wireless network, to the one or more other devices, an indication of availability of the remaining portion of the TXOP period for data transmissions; and

allocate, responsive to one or more responses to the indication from the one or more other devices, the remaining portion of the TXOP period to a second device of the one or more other devices to transmit data of the second device during the remaining portion of the TXOP period.

2. The system of claim **1**, wherein the first device is further configured to:

schedule a transmission of data of the first device during the first portion of the TXOP period; and

determine, responsive to a determination that the scheduled transmission occupying the first portion of the TXOP period is to be completed prior to a start of the remaining portion, that the remaining portion of the TXOP period is available for the one or more other devices to transmit low latency data during the remaining portion.

3. The system of claim **1**, wherein the first device is further configured to:

determine, based on a response of the one or more responses of the second device, that the data of the second device is low latency data; and

allocate, responsive to the data of the second device being low latency data, the remaining portion to the second device.

4. The system of claim **1**, wherein the first device is further configured to:

identify that a first data of the one or more transmissions of the first device is of a first priority;

identify that a second data of a second one or more transmissions to be transmitted by the first device is of a second priority lower than the first priority; and

determine, responsive to the second data being of the second priority, to transmit the indication of availability.

5. The system of claim **1**, wherein the first device is further configured to schedule, for the second device, a transmission of the data of the second device that is low latency data, for at least a first part of the remaining portion of the TXOP period.

6. The system of claim **5**, wherein the first device is further configured to schedule, for a third device of the one or more other devices of the wireless network, a transmission of a data of the third device that is low latency data for at least a second part of the remaining portion of the TXOP period, the second part following the first part.

7. The system of claim **1**, wherein the first device is further configured to:

transmit the indication to the one or more other devices via one or more physical protocol data units (PPDUs);

receive, from the one or more other devices, one or more block acknowledgements (BAs) responsive to the one or more PPDUs, the one or more BAs comprising the one or more responses indicated using one or more bits of one or more fields of the one or more BAs; and

select, based on the one or more bits of the one or more fields of the one or more BAs, the second device.

8. The system of claim **1**, wherein the first device is further configured to:

identify, for a plurality of the one or more other devices, a corresponding plurality of random delays within the TXOP period, each random delay of the plurality of random delays for each device of the one or more other devices different from each other random delay of the plurality of delays of each other device of the one or more other devices;

select, from the one or more other devices, the second device based on a respective random delay of the second device; and

allocate the remaining portion of the TXOP period to the second device in response to the selection.

9. The system of claim **8**, wherein each of the plurality of random delays corresponds to a timing for transmitting a respective response of the one or more responses by a respective device of the one or more other devices, and wherein the selection of the second device is based on a respective timing of the random delay of the second device such that the response from the second device is received by the first device before other respective responses of other respective remaining devices.

10. The system of claim **1**, wherein the first device is further configured to:

determine that the second device has completed a transmission of the data of the second device during a first part of the remaining portion of the TXOP period; and

determine to transmit a second one or more transmissions of the first device over the wireless network during a second part of the remaining portion of the TXOP period, the second part following the first part.

11. The system of claim **1**, wherein the first device comprises a wireless local area network (WLAN) access point (AP) device and the second device comprises a client device associated with the WLAN AP device.

12. The system of claim **1**, wherein the first device comprises a client device of a wireless local area network (WLAN) access point (AP) device and the second device comprises the WLAN AP device, and wherein the first device is further configured to:

identify uplink data of the first device to transmit to the second device; and

determine, based on the uplink data, to allocate the remaining portion of the TXOP period to the second device for the second device to transmit downlink data to the first device.

13. The system of claim 12, wherein the first device is configured to determine to allocate the remaining portion of the TXOP period to the second device based on an amount of the uplink data satisfying a threshold.

14. The system of claim 1, wherein the first device comprises a first client device associated with a wireless local area network (WLAN) access point (AP) device and the second device comprises a second client device associated with the WLAN AP device and wherein the first device is further configured to allocate the remaining portion of the TXOP period to the second device for peer to peer communications.

15. A method, comprising:

identifying, by a first device of a wireless local area network (WLAN) granted a transmission opportunity (TXOP) for transmissions during a TXOP period, a first portion of the TXOP period for one or more transmissions of the first device over the WLAN;

determining, by the first device, that a remaining portion of the TXOP period subsequent to the first portion is available for data transmissions of one or more other devices of the WLAN;

transmitting, by the first device, via the WLAN, to the one or more other devices, an indication of availability of the remaining portion of the TXOP period for data transmissions; and

allocating, by the first device, responsive to one or more responses to the indication from the one or more other devices, the remaining portion of the TXOP period to a second device of the one or more other devices to transmit data of the second device during the remaining portion of the TXOP period.

16. The method of claim 15, comprising:

scheduling, by the first device, a transmission of data of the first device during the first portion of the TXOP period; and

determining, by the first device, responsive to a determination that the scheduled transmission occupying the first portion of the TXOP period is to be completed prior to a start of the remaining portion, that the remaining portion of the TXOP period is available for the one or more other devices to transmit low latency data during the remaining portion.

17. The method of claim 15, comprising:

determining, by the first device, based on a response of the one or more responses of the second device, that the data of the second device is low latency data; and

allocating, by the first device, responsive to the data of the second device being low latency data, the remaining portion to the second device.

18. The method of claim 15, comprising:

identifying, by the first device, that a first data of the one or more transmissions of the first device is of a first priority;

identifying, by the first device, that a second data of a second one or more transmissions to be transmitted by the first device is of a second priority lower than the first priority; and

determining, by the first device, responsive to the second data being of the second priority, to transmit the indication of availability.

19. The method of claim 15, comprising scheduling, for the second device, a transmission of the data of the second device that is low latency data, for at least a first part of the remaining portion of the TXOP period.

20. A non-transitory computer-readable medium storing instructions that, when executed by at least one processor of a first device a wireless local area network (WLAN) that is granted a transmission opportunity (TXOP) for transmissions during a TXOP period, cause the at least one processor to:

identify a first portion of the TXOP period for one or more transmissions of the first device over the WLAN;

determine that a remaining portion of the TXOP period subsequent to the first portion is available for data transmissions of one or more other devices of the WLAN;

transmit, via the WLAN, to the one or more other devices, an indication of availability of the remaining portion of the TXOP period for data transmissions; and

allocate, responsive to one or more responses to the indication from the one or more other devices, the remaining portion of the TXOP period to a second device of the one or more other devices to transmit data of the second device during the remaining portion of the TXOP period.

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