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INT CL **H04W**
Other: **On-Line - EPODOC, INSPEC, WPI**

(54) Title of the Invention: **Methods apparatus and computer program for configuring wireless transmissions**
Abstract Title: **Simultaneous transmission of uplink and downlink data in a wireless network**

(57) Systems and. techniques are disclosed for configuring wireless transmissions, in particular to achieve full-duplex wireless networking between a wireless network access point and a wireless network station. An access point configures a transmit opportunity (TXOP) 302 in a contention free period (CFP) 300 to provide for a full-duplex mode, including at least one uplink frame 304A for transmission by a station and. at least one downlink frame 306A for transmission by the access point. The uplink mode and the downlink mode provide for simultaneous transmission. The transmit opportunity 302 may be configured so that uplink frames 304A and their corresponding downlink frames 306A are of equal duration, either through configuring frames to be of equal duration, or by adjusting frame durations during transmission. May be used in a WLAN operating under the IEEE 802.11 standard.

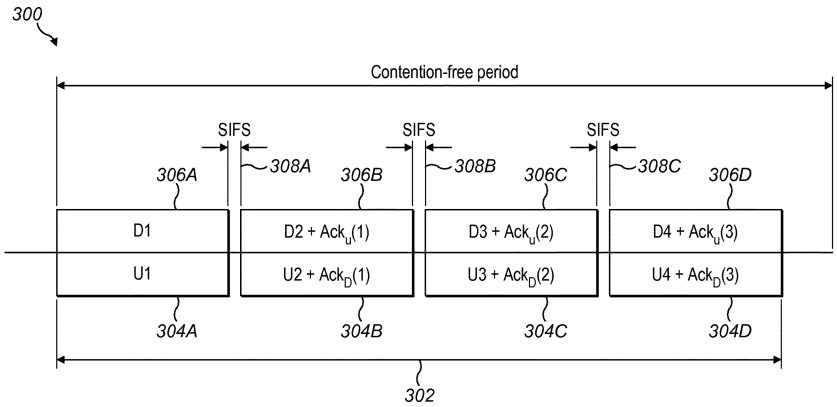

FIG. 3

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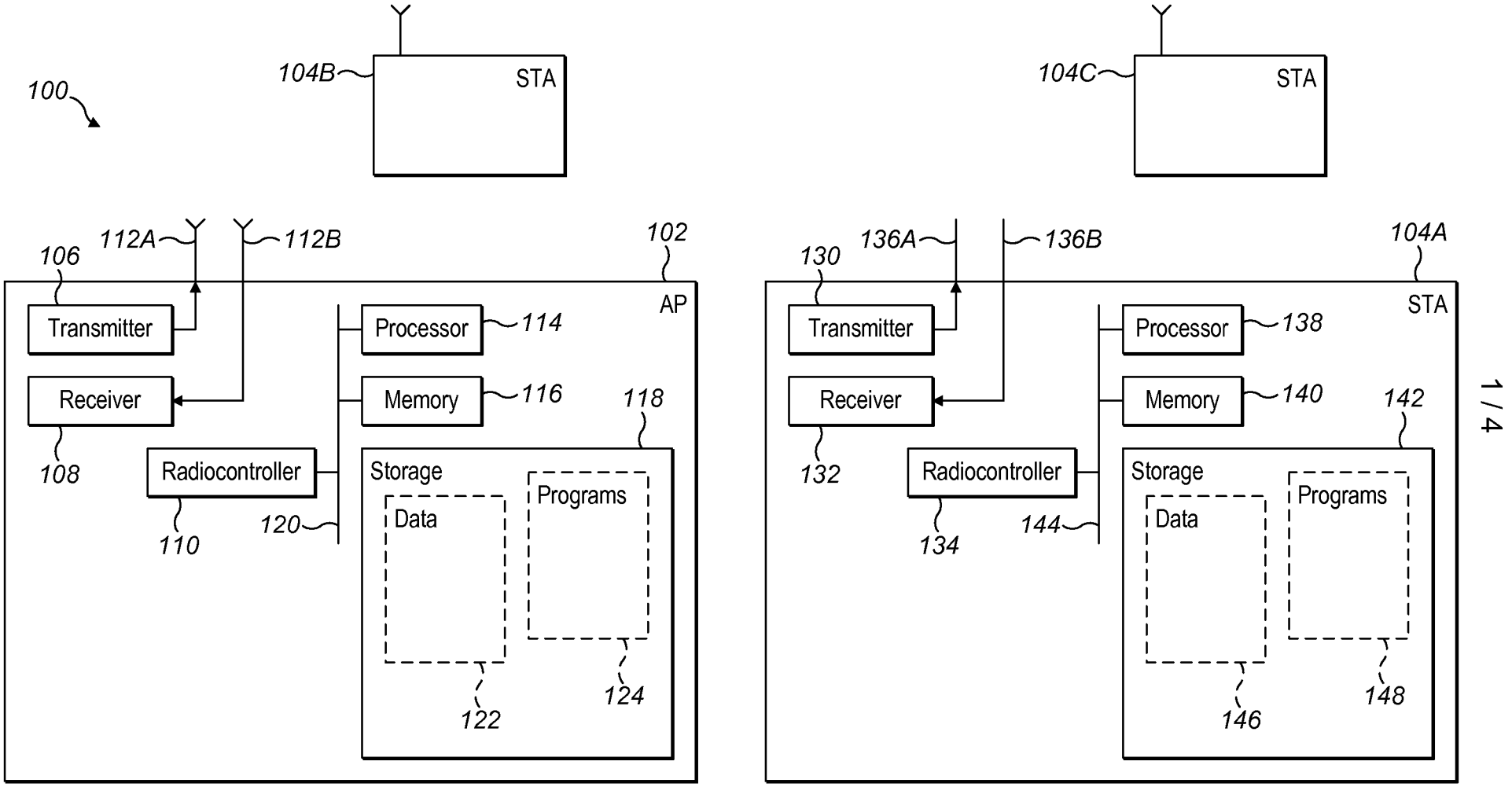
100
104B
STA
104C
STA
102
AP
106
112A
112B
Transmitter
Receiver
108
Radiocontroller
110
120
Processor
114
Memory
116
118
Storage
Data
122
Programs
124
104A
STA
130
136A
136B
Transmitter
Receiver
132
Radiocontroller
134
144
Processor
138
Memory
140
142
Storage
Data
146
Programs
148

FIG. 1

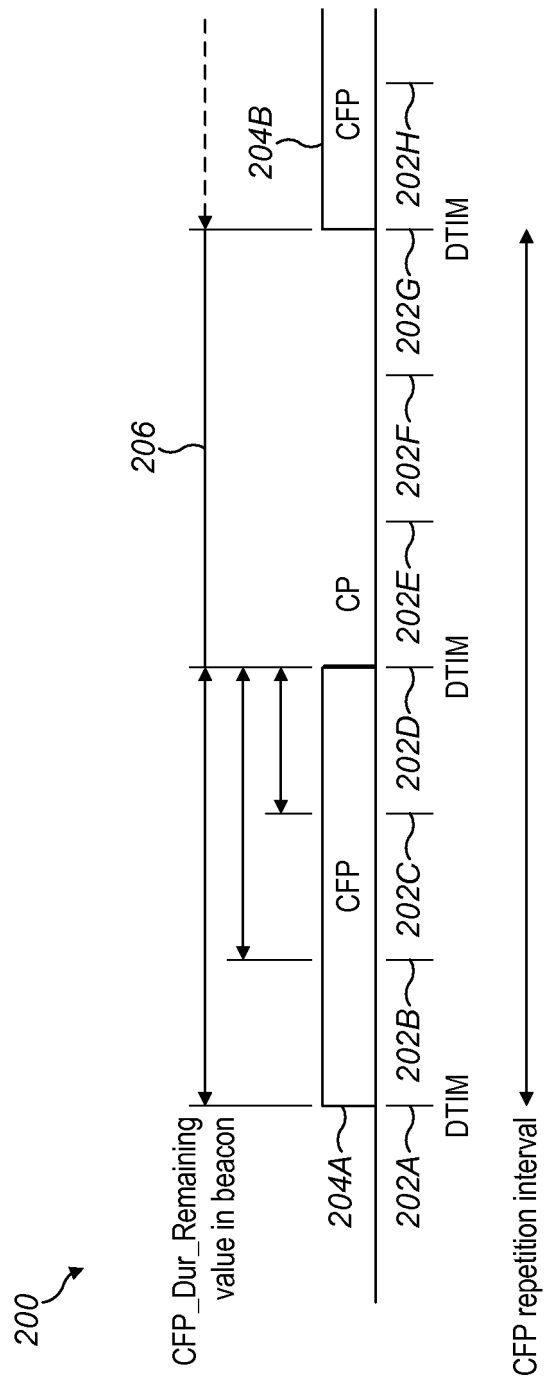
200
CFP_Dur_Remaining value in beacon
204A
202A
202B
DTIM
202C
CFP
202D
202E
CP
DTIM
202F
202G
206
204B
CFP
202H
DTIM
CFP repetition interval

FIG. 2

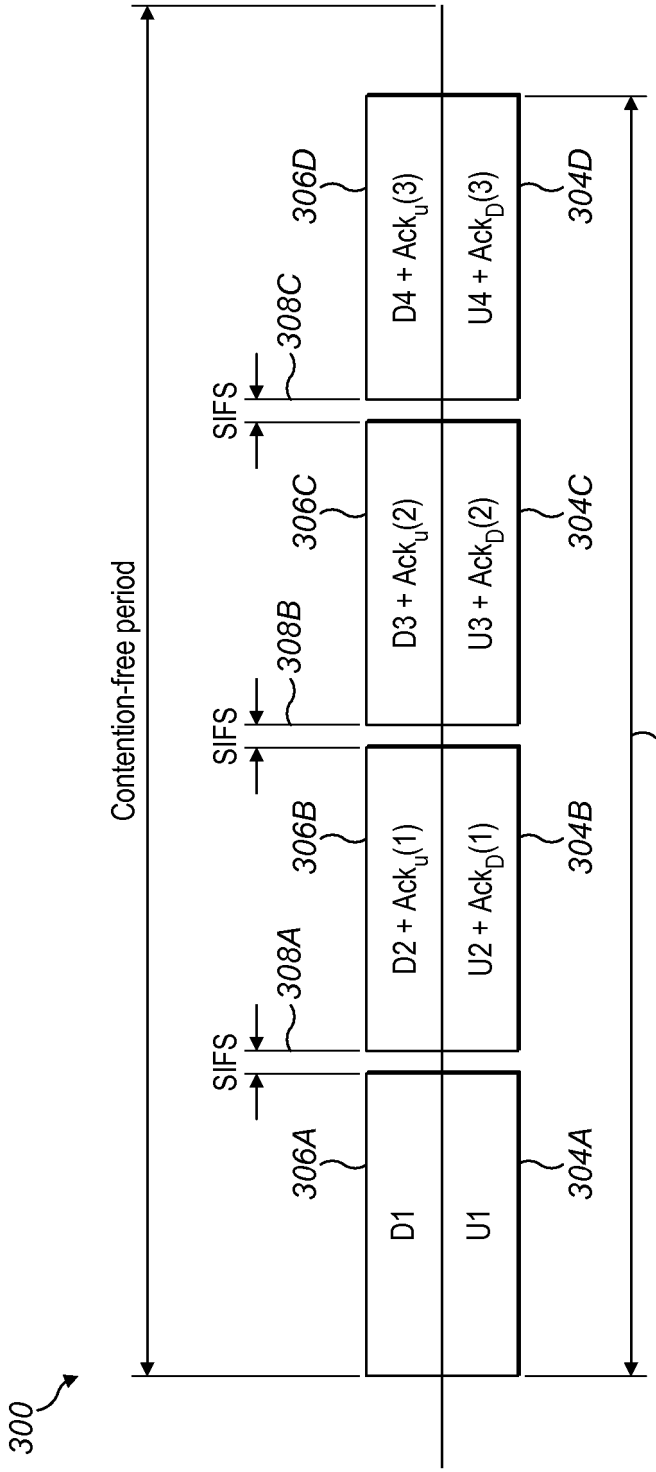
300
Contention-free period
302
SIFS
SIFS
SIFS
306A
306B
306C
306D
308A
308B
308C
304A
304B
304C
304D
D1
U1
D2 + Ack$_u$(1)
U2 + Ack$_D$(1)
D3 + Ack$_u$(2)
U3 + Ack$_D$(2)
D4 + Ack$_u$(3)
U4 + Ack$_D$(3)

FIG. 3

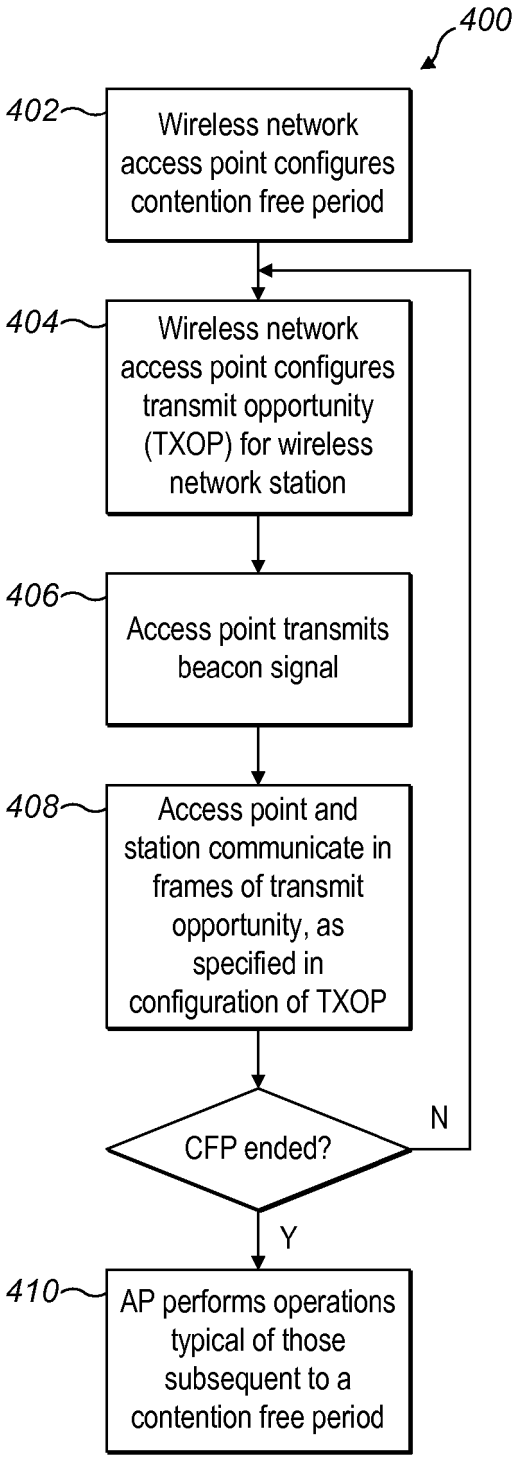
400
402
Wireless network access point configures contention free period
404
Wireless network access point configures transmit opportunity (TXOP) for wireless network station
406
Access point transmits beacon signal
408
Access point and station communicate in frames of transmit opportunity, as specified in configuration of TXOP
CFP ended?
N
Y
410
AP performs operations typical of those subsequent to a contention free period

FIG. 4

METHODS, APPARATUS AND COMPUTER PROGRAM FOR CONFIGURING WIRELESS TRANSMISSIONS

Technical Field

The present invention relates to methods, apparatus and computer program for configuring wireless transmissions. The exemplary and non-limiting embodiments of this invention relate generally to wireless communication. In particular embodiments, the invention relates to full-duplex communication by a node of a communications network.

Background

Wireless communication, such as communication over wireless local area networks, is steadily becoming more popular and widespread. For example, the increasing popularity and wider use of wireless networking places increasing demands on the infrastructure and radio resources used for wireless networking. In addition, the radio resources used for wireless networking are increasingly being put to other uses, so that wireless networking needs to share radio resources with more and more applications. Any increase in efficiency in the use of wireless networking infrastructure and radio resources is therefore highly desirable. Similar considerations apply to other wireless communication mechanisms.

Summary

According to a first aspect of the present invention, there is provided apparatus for use in a wireless network access point, the apparatus comprising a processing system constructed and arranged to cause the apparatus to perform actions comprising at least: defining a transmit opportunity for a wireless network station, wherein the transmit opportunity comprises at least one uplink frame for an uplink transmission by the station to the access point; and if the access point has data for the wireless network station, configuring at least one downlink frame for downlink transmission from the access point to the wireless network station, wherein the downlink frame is configured so that the uplink and the downlink transmissions occur simultaneously.

The processing system may comprise at least one processor and memory storing computer program code, the computer program code being configured to, with the memory and the at least one processor, cause the apparatus to perform actions as described above.

According to a second aspect of the present invention, there is provided a method comprising: configuring at least one processor to cause an apparatus to perform actions comprising at least: defining a transmit opportunity for a wireless network station, wherein the transmit opportunity comprises at least one uplink frame for an uplink transmission by the station to the access point; and if the access point has data for the wireless network station, configuring at least one downlink frame for downlink transmission from the access point to the wireless network station, wherein the downlink frame is configured so that the uplink and the downlink transmissions occur simultaneously.

According to a third aspect of the present invention, there is provided a computer program comprising instructions, execution of which by a processor configures an apparatus to perform actions comprising at least: defining a transmit opportunity for a wireless network station, wherein the transmit opportunity comprises at least one uplink frame for an uplink transmission by the station to the access point; and if the access point has data for the wireless network station, configuring at least one downlink frame for downlink transmission from the access point to the wireless network station, wherein the downlink frame is configured so that the uplink and the downlink transmissions occur simultaneously.

The computer program may be provided as a computer readable medium for use in a wireless network access point and which stores the program of instructions.

According to a fourth aspect of the present invention, there is provided a method of configuring wireless transmissions, the method comprising: defining a

transmit opportunity for a wireless network station, wherein the transmit opportunity comprises at least one uplink frame for an uplink transmission by the station to a wireless network access point; and if the access point has data for the wireless network station, configuring at least one downlink frame for downlink transmission from the access point to the wireless network station, wherein the downlink frame is configured so that the uplink and the downlink transmissions occur simultaneously.

Further features and advantages of the invention will become apparent from the following description of preferred embodiments of the invention, given by way of example only, which is made with reference to the accompanying drawings.

Brief Description of the Drawings

Fig. 1 shows schematically an example of a wireless network according to an embodiment of the present invention;

Fig. 2 shows a diagram showing an example of communication intervals defined according to an embodiment of the present invention;

Fig. 3 shows a diagram showing an example of communication between network elements according to an embodiment of the present invention; and

Fig. 4 shows schematically an example of a process according to an embodiment of the present invention.

Detailed Description

Examples of embodiments of the present invention recognise that wireless networking, like most wireless applications, involves uplink transmissions and downlink transmissions. Naturally, simultaneous uplink and downlink transmission on the same frequency and at the same time can increase efficiency in the use of infrastructure and resources. Examples of embodiments of the present invention provide mechanisms for full duplex transmission by a wireless network access point.

That is, examples of embodiments of the invention allow for downlink transmission by an access point while a wireless network station is engaged in uplink transmission to the access point.

The discussion below is primarily in the context of wireless networking conducted under the 802.11 standard, but it will be recognised that this discussion is exemplary and non-limiting, and that any number of mechanisms for scheduled transmissions from one communications node to another may use embodiments of the present invention in licensed or unlicensed spectrum. A receiving node to which full-duplex transmission and reception is available is thus able to use embodiments of the present invention to transmit and receive at the same time.

One or more embodiments of the invention may be employed in wireless networks operating according to the IEEE 802.11 standard, and such networks may be referred to as 802.11 networks. An 802.11 wireless network typically comprises at least one access point (AP) serving one or more stations (STAs), using radio resources that may be shared with other wireless networks and with a variety of other users. Wireless networks typically operate according to protocols designed to prevent any one user from monopolising the available resources. Possible modes of operation for wireless networks include a hybrid coordination function (HCF) and a point coordination function (PCF). The PCF and the HCF modes of operation include a contention free period (CFP) and a contention period (CP). During the contention free period, the AP is able to take control of a wireless channel for its own traffic and also to schedule transmission from STAs.

Fig. 1 illustrates schematically an example of a wireless network 100 according to one or more embodiments of the present invention. The network 100 comprises an access point (AP) 102 and stations (STAs) 104A-104C. The AP 102 and STAs 104A-104C may operate in HCF mode. In HCF mode, the STAs are allowed a period of time, called a transmit opportunity (TXOP), to transmit to the AP. A TXOP is defined by its starting time and its maximum duration. The TXOPs given

to STAs by the AP during controlled channel access are called HCF controlled channel access (HCCA) TXOPs, or polled TXOPs. During an HCCA TXOP, a STA can transmit multiple frames as long as the maximum duration of the TXOP is not exceeded. Each contention free period (CFP) begins after a beacon frame, and extends for the duration specified in a delivery traffic indication message (DTIM). The DTIM indicates the client stations (STAs) that are currently in low-power mode that have data buffered on the access point awaiting pickup.

Additional details of the AP 102 and the STA 102A are illustrated here, with the understanding that the STAs 104B and 104C may include similar elements as those described with respect to the STA 104A.

The AP 102 may comprise a transmitter 106, receiver 108, radio controller 110, and antennas 112A and 112B. The AP 102 may further comprise a processor 114, memory 116, and storage 118, communicating with one another and with the radio controller over a bus 120. The AP 102 may further comprise data 122 and programs 124, suitably residing in storage 118 and transferred to memory 116 as needed for use by the processor 114.

The STA 104A may comprise a transmitter 130, receiver 132, radio controller 134, and antennas 136A and 136B. The STA 104A may further comprise a processor 138, memory 140, and storage 142, communicating with one another and with the radio controller over a bus 144. The AP 102 may further comprise data 146 and programs 148, suitably residing in storage 142 and transferred to memory 140 as needed for use by the processor 138.

Any or all of the STAs 104A-104C and other similar devices may be implemented as any device capable of engaging in wireless network communication. For example, a cellular telephone or other mobile communication device may be equipped to operate in a cellular network and may simultaneously be equipped and configured to operate as a wireless network station, and may employ one or more

embodiments of the present invention. One example of a mobile communication device that may employ one or more embodiments of the present invention is a user equipment (UE). The term "user equipment" refers to a device capable of performing data processing and wireless communication. User equipment include devices that use a subscriber identification module (SIM), and also include devices that carry out wireless communication without the use of a SIM. User equipment may include, but are not limited to, the following types of devices: mobile phone, smartphone, personal digital assistant (PDA), tablet computer, laptop computer, camera, notebook computer, portable game console, and electronic reader. A UE may, but need not be, a portable device, and other examples of UEs include tower computers, in-home game consoles, network equipped disc players, audio receivers, media servers, and television sets.

Fig. 2 illustrates a diagram 200 illustrating an example of the generation of contention free periods. The diagram 200 illustrates the relative timing of different events, including frames 202A-202H, contention free periods 204A and 204B, and a contention period 206. One or more beacons transmitted before the CFP include information defining the remaining CFP value, as can be seen with respect to the frames 202A, 202B, and 202C. In the presently illustrated embodiment, the contention period 206 begins after the contention free period 204A but this is non-limiting and the contention period may be configured to precede the contention free period .

In one or more embodiments of the invention, the AP transmits during an HCCA TXOP if it has data to send in the downlink. In the case of the network 100, the AP 102 synchronises its downlink transmission with the uplink transmission from a STA with which it is communicating. The AP 102 waits during the interval defined by the short interframe space (SIFS) and then transmits in the downlink again, to the same STA.

As an alternative to transmitting to the same STA, the AP 102 may, after the SIFS, transmit to another STA in the downlink, providing that the communication requirements of the network 100 allow for receiving from one STA and transmitting to a different STA using full duplex mode.

Fig. 3 illustrates details of an example of a contention free period 300 according to an embodiment of the present invention. A TXOP 302 for transmission by a STA to an AP is defined for the contention free period 300. The TXOP 302 comprises uplink frames 304A, 304B, 304C, and 304D, and downlink frames 306A, 306B, 306C, and 306D. An uplink frame and its corresponding downlink frame occupy the same duration, and pairs of corresponding frames are separated by SIFS intervals 308A, 308B, and 308C. During the TXOP 302, the AP is operating in a full-duplex mode, in which it transmits data to the STA on the downlink while receiving data from the STA on the uplink. Use of the full-duplex mode by the AP may be specified by elements of a traffic indication map (TIM), which may indicate data to be transmitted by the AP and the STA or STAs to which the data is to be directed. If the TIM indicates that the AP has data to transmit, the AP may perform downlink transmissions simultaneously with uplink transmissions from the STA. After the end of the CFP 300, a contention period will begin, similarly to the scenario illustrated above in Fig. 2. After the contention period, a new CFP will begin, with the scheduling of an STA and the operation of the AP defined, for example, by a traffic indication map indicating the traffic demands for a new TXOP.

In one embodiment of the invention, the AP schedules uplink transmissions by the STA and performs downlink transmissions to the same STA during the time scheduled for uplink transmissions by the STA. For example, during the frame 306A, uplink data U1 is transmitted by the STA and downlink data D1 is transmitted by the AP. After an SIFS interval 308A, the frames 304B and 306B begin. Data U2 is transmitted by the STA and data D2 is transmitted by the AP. In addition to transmitting data during the frame 306B, the AP may transmit an acknowledgement that data U1 was received, and the STA may transmit an acknowledgement that data

D1 was received. Similarly, in frames 304C and 306C, and 304D and 306D, data is transmitted by the STA in the uplink and by the AP in the downlink, and acknowledgement frames may similarly be sent in the uplink and the downlink. In Fig. 3, D*i* indicates the *i*th downlink frame from the AP and U*i* indicates the *i*th uplink frame from an STA. $Ack_U(i)$ is the acknowledgement of the *i*th uplink transmission and $Ack_D(i)$ is the acknowledgement of the *i*th downlink transmission.

In one embodiment of the invention, data and acknowledgement fields are specified in each frame. Numerous alternative designs may be configured. For example, acknowledgement fields need not appear in every frame. In at least one embodiment of the invention, a single block acknowledgement may be sent, in order to acknowledge all frames in the TXOP. In this configuration, only data need be sent. It will also be recognised that the AP will not always have data to transmit and the STA may send data in an uplink frame without a need to transmit data in the downlink frame.

In one or more embodiments of the invention, the AP disables the full-duplex mode if it has no data. In at least one other embodiments of the invention, the AP disables the full-duplex mode if no data is received from the STA within a specified time from a particular event. In the case in which the AP receives no data from the STA, the TXOP may be truncated and a new TXOP granted to another STA.

It will be recognised that embodiments may be designed wherein the full-duplex mode is disabled if either the AP has no data or no data is received from the STA.

For example, if the SIFS duration passes after the last transmission received by the AP from the STA, the AP may assume that the STA has no more data, and may truncate the TXOP. Such an occurrence may result in the loss of the contention free end frame (CF-End frame) of the TXOP, or of a data frame of the TXOP. Alternatively, the STA or AP may detect that it has no data to send during the CF

period and may explicitly indicate that it has no more data. Such an indication may be delivered by including an explicit "no more data" indication in the last frame in which data is transmitted. If the STA indicates that it has no data to send, a CF-End is sent individually to indicate termination of the TXOP.

In at least one embodiment of the invention, the HCCA coordinate data uplink and downlink frame durations. Frame durations for uplink and downlink data may be equal based on queue size at the STA and the TXOP duration. If the STA or AP cannot fill the indicated frame by multiplexing several media access control (MAC) frames and acknowledgements (ACKs) or adjusting the MCS, padding is used to reach a target length for the frame. In this way, the duration of the AP transmission and the STA transmission can be equalised, allowing for coordination of the SIFS periods for the STA and the AP.

In one or more embodiments of the invention, the HCCA allows dynamic adjustment of frame duration. For example, if the STA or AP finishes its transmission before its counterpart, that is if the STA finishes its transmission before the AP, or the AP finishes its transmission before the STA, the frame duration is determined by the duration of the longer transmission. The duration of the SIFS period is determined following the termination of the longer duration transmission.

In one or more embodiments, the AP attempts to synchronise its transmissions to those of the STA. Therefore, in one or more embodiments of the invention, the AP is provided with information indicating the duration of the transmission frames. For example, frame duration information can be included in the media access control (MAC) header. The MAC header may include information regarding the length of the jth frame in the future that a STA will generate. For example, the value of j may be 0 to indicate the current frame, 1 to indicate the next frame, 2 to indicate 2 frames in the future, and so on.

To take another alternative, frame duration information can be included in the PHY header. The PHY header can include information regarding the length of the *j*th frame in the future that a STA can generate.

Once the AP has obtained frame length information, it can synchronise its own transmission by choosing its MCS and frame lengths appropriately. It is possible that the beginning of the uplink and the downlink transmissions will not be synchronised. For example, the downlink may start after being shifted by a time needed to decode header information. However, because the AP is aware of the duration of the STA's uplink transmission, and because it knows the time shift for the downlink, the AP will know the starting time of the downlink and the finishing time of the uplink, and can coordinate the duration of the downlink to end at the same time as the uplink. The AP downlink and the STA uplink can therefore be coordinated to finish at the time when the SIFS will be measured.

For example, if the STA indicates a frame length that is smaller than the frame length the AP is to send, the AP may fragment its data so as to transmit its data in multiple smaller frames. If the STA indicates a frame length that is longer than the AP's intended frame length, the AP may pad its frame accordingly.

Fig. 4 illustrates schematically an example of a process 400 of wireless networking communication according to an embodiment of the present invention. At step 402, a wireless network access point configures a contention free period. The configuration may specify behaviour of the access point during the contention free period, as well as scheduling for STAs and frame and SIFS duration and adjustment occurring during the contention free period.

At step 404, the access point configures a transmit opportunity for a wireless network station (STA), specifying the specific STA that is to be allowed to transmit, and scheduling information for the transmission. Configuration of the transmit opportunity may also specify characteristics and use of frames that may be used

simultaneously by the AP and the STA for downlink and uplink transmission, respectively. The frames may be specified so that uplink and downlink frames end at the same time and allow for simultaneous and equal SIFS durations between frames. For example, configuration information may specify that frames are equal in duration, or alternatively may specify that frames may be variable based on particular choices and conditions. For example, an uplink frame may be extended to match the duration of its corresponding downlink frame, or vice versa. Such an extension may be performed during the actual transmission of the longer frame. In an alternative, configuration information may specify that the access point will synchronise the duration of its downlink frame to the duration of the STA's uplink frame, based on information provided by the STA.

Configuration of the TXOP may also specify the behaviour of the AP during the TXOP. For example, the AP may be configured not to transmit in a downlink frame if it has no data to transmit, or may alternatively or in addition be configured not to transmit, and to truncate the TXOP, if it receives no transmission from the STA within a specified time. As a further alternative, one or both of the AP and the STA may be configured to specifically signal to the other that it has no data to transmit, and the AP may also be configured to send an indication ending a contention free period.

At step 406, the access point transmits a beacon signal, which may provide configuration information indicating the configuration of the TXOP, and the behaviour specified for the STA and the AP. The beacon signal is transmitted before the contention-free period or during the contention period, and defines the behaviour of the AP and STA during the following contention-free and contention periods respectively.

At step 408, the STA and the AP communicate in frames of the TXOP, as specified in the configuration of the TXOP. The AP and STA may communicate in uplink and downlink frames when the AP has data to transmit, and the frame durations may be configured as specified. Both the AP and the STA may send an

acknowledgement signal after every data frame that is successfully received, or, depending on the specified configuration, may indicate acknowledgement in other ways, such as sending a single acknowledgement signal at the end of the TXOP.

If the contention free period has not yet ended, the process may return to step 404 and another TXOP may be configured. If the contention period has ended, the process proceeds to step 410, and the AP performs operations typical of those subsequent to a contention-free period, such as entering a contention period or other operations.

The above embodiments are to be understood as illustrative examples of the invention. Further embodiments of the invention are envisaged. It is to be understood that any feature described in relation to any one embodiment may be used alone, or in combination with other features described, and may also be used in combination with one or more features of any other of the embodiments, or any combination of any other of the embodiments. Furthermore, equivalents and modifications not described above may also be employed without departing from the scope of the invention, which is defined in the accompanying claims.

CLAIMS

1. Apparatus for controlling a wireless network access point, the apparatus comprising a processing system constructed and arranged to cause the apparatus to perform actions comprising at least:

defining a transmit opportunity for a wireless network station, wherein the transmit opportunity comprises at least one uplink frame for an uplink transmission by the station to the access point; and

if the access point has data for the wireless network station, configuring at least one downlink frame for downlink transmission from the access point to the wireless network station, wherein the downlink frame is configured so that the uplink and the downlink transmissions occur simultaneously at the same frequency at the same time.

2. Apparatus according to claim 1, wherein defining the transmit opportunity and configuring that at least one downlink frame comprise configuring a plurality of uplink and a plurality of downlink frames.

3. Apparatus according to claim 2, wherein defining the uplink and downlink frames comprises defining at least one uplink frame to include an acknowledgement for a preceding downlink transmission and at least one downlink frame to include an acknowledgement for a preceding uplink transmission.

4. Apparatus according to claim 2 or claim 3, wherein defining the uplink and the downlink frames comprises defining at least one uplink frame to include an acknowledgement for multiple preceding downlink transmission and defining at least one downlink frame to include an acknowledgement for multiple preceding uplink transmissions.

5. Apparatus according to any of claims 1 to 4, wherein defining the transmit opportunity comprises configuring downlink transmission to terminate if no data is present to be transmitted to the station.

6. Apparatus according to any of claims 1 to 5, wherein defining the transmit opportunity comprises configuring the downlink transmission to terminate if no transmission is received from the station after a specified time.

7. Apparatus according to any of claims 1 to 6, wherein defining the transmit opportunity comprises configuring the downlink transmission to terminate if an explicit indication is received that the downlink transmission is to terminate.

8. Apparatus according to any of claims 1 to 7, wherein defining the transmit opportunity comprises configuring the uplink and downlink frames to be of equal duration.

9. Apparatus according to any of claims 1 to 8, wherein defining the transmit opportunity comprises configuring the uplink and downlink frames to be of fixed duration.

10. Apparatus according to any of claims 1 to 9, wherein defining the transmit opportunity comprises configuring the transmission so that during transmission at least one of the uplink frame and the downlink frame is adjusted so that the uplink frame and the downlink frame terminate simultaneously.

11. Apparatus according to any of claims 1 to 10, wherein the apparatus is configured to operate according to the IEEE 802.11 wireless networking standard.

12. Apparatus according to any of claims 1 to 11, wherein the apparatus is a user equipment.

13. A method comprising:

configuring at least one processor to cause an apparatus to perform actions comprising at least:

defining a transmit opportunity for a wireless network station, wherein the transmit opportunity comprises at least one uplink frame for an uplink transmission by the station to a wireless network access point; and

if the access point has data for the wireless network station, configuring at least one downlink frame for downlink transmission from the access point to the wireless network station, wherein the downlink frame is configured so that the uplink and the downlink transmissions occur simultaneously.

14. A method according to claim 13, wherein defining the transmit opportunity and configuring that at least one downlink frame comprise configuring a plurality of uplink and a plurality of downlink frames.

15. A method according to claim 14, wherein defining the uplink and downlink frames comprises defining at least one uplink frame to include an acknowledgement for a preceding downlink transmission and at least one downlink frame to include an acknowledgement for a preceding uplink transmission.

16. A method according to claim 14 or claim 15, wherein defining the uplink and the downlink frames comprises defining at least one uplink frame to include an acknowledgement for multiple preceding downlink transmission and defining at least one downlink frame to include an acknowledgement for multiple preceding uplink transmissions.

17. A method according to any of claims 13 to 16, wherein defining the transmit opportunity comprises configuring the downlink transmission to terminate if no data is present to be transmitted to the station.

18. A method according to any of claims 13 to 17, wherein defining the transmit opportunity comprises configuring the downlink transmission to terminate if no transmission is received from the station after a specified time.

19. A method according to any of claims 13 to 18, wherein defining the transmit opportunity comprises configuring the downlink transmission to terminate if an explicit indication is received that the downlink transmission is to terminate.

20. A method according to any of claims 13 to 19, wherein defining the transmit opportunity comprises configuring the uplink and downlink frames to be of equal duration.

21. A method according to any of claims 13 to 20, wherein defining the transmit opportunity comprises configuring the uplink and downlink frames to be of fixed duration.

22. A method according to any of claims 13 to 21, wherein defining the transmit opportunity comprises configuring the transmission so that during transmission at least one of an uplink frame and a downlink frame is adjusted so that the uplink frame and the downlink frame terminate simultaneously.

23. A computer program comprising instructions, execution of which by a processor configures an apparatus to perform actions comprising at least:

defining a transmit opportunity for a wireless network station, wherein the transmit opportunity comprises at least one uplink frame for an uplink transmission by the station to a wireless network access point; and

if the access point has data for the wireless network station, configuring at least one downlink frame for downlink transmission from the access point to the wireless network station, wherein the downlink frame is configured so that the uplink and the downlink transmissions occur simultaneously.

24. A computer program according to claim 23, wherein defining the transmit opportunity and configuring that at least one downlink frame comprise configuring a plurality of uplink and a plurality of downlink frames.

25. A computer program according to claim 24, wherein defining the uplink and downlink frames comprises defining at least one uplink frame to include an acknowledgement for a preceding downlink transmission and at least one downlink frame to include an acknowledgement for a preceding uplink transmission.

26. A computer program according to claim 24 or claim 25, wherein defining the uplink and the downlink frames comprises defining at least one uplink frame to include an acknowledgement for multiple preceding downlink transmission and defining at least one downlink frame to include an acknowledgement for multiple preceding uplink transmissions.

27. A computer program according to any of claims 23 to 26, wherein defining the transmit opportunity comprises configuring the downlink transmission to terminate if no data is present to be transmitted to the station.

28. A computer program according to any of claims 23 to 27, wherein defining the transmit opportunity comprises configuring the downlink transmission to terminate if no transmission is received from the station after a specified time.

29. A computer program according to any of claims 23 to 28, wherein defining the transmit opportunity comprises configuring the downlink transmission to terminate if an explicit indication is received that the downlink transmission is to terminate.

30. A computer program according to any of claims 23 to 29, wherein defining the transmit opportunity comprises configuring the uplink and downlink frames to be of equal duration.

31. A computer program according to any of claims 23 to 30, wherein defining the transmit opportunity comprises configuring the uplink and downlink frames to be of fixed duration.

32. A computer program according to any of claim 23 to 31, wherein defining the transmit opportunity comprises configuring the transmission so that during transmission at least one of an uplink frame and a downlink frame is adjusted so that the uplink frame and the downlink frame terminate simultaneously.

33. A method of configuring wireless transmissions, the method comprising:

defining a transmit opportunity for a wireless network station, wherein the transmit opportunity comprises at least one uplink frame for an uplink transmission by the station to a wireless network access point; and

if the access point has data for the wireless network station, configuring at least one downlink frame for downlink transmission from the access point to the wireless network station, wherein the downlink frame is configured so that the uplink and the downlink transmissions occur simultaneously.

34. A method according to claim 33, wherein defining the transmit opportunity and configuring that at least one downlink frame comprise configuring a plurality of uplink and a plurality of downlink frames.

35. A method according to claim 34, wherein defining the uplink and downlink frames comprises defining at least one uplink frame to include an acknowledgement for a preceding downlink transmission and at least one downlink frame to include an acknowledgement for a preceding uplink transmission.

36. A method according to claim 34 or claim 35, wherein defining the uplink and the downlink frames comprises defining at least one uplink frame to include an acknowledgement for multiple preceding downlink transmission and defining at least

one downlink frame to include an acknowledgement for multiple preceding uplink transmissions.

37. A method according to any of claims 33 to 36, wherein defining the transmit opportunity comprises configuring the downlink transmission to terminate if no data is present to be transmitted to the station.

38. A method according to any of claims 33 to 37, wherein defining the transmit opportunity comprises configuring the downlink transmission to terminate if no transmission is received from the station after a specified time.

39. A method according to any of claims 33 to 38, wherein defining the transmit opportunity comprises configuring the downlink transmission to terminate if an explicit indication is received that the downlink transmission is to terminate.

40. A method according to any of claims 33 to 39, wherein defining the transmit opportunity comprises configuring the uplink and downlink frames to be of equal duration.

41. A method according to any of claims 33 to 40, wherein defining the transmit opportunity comprises configuring the uplink and downlink frames to be of fixed duration.

42. A method according to any of claims 33 to 41, wherein defining the transmit opportunity comprises configuring the transmission so that during transmission at least one of an uplink frame and a downlink frame is adjusted so that the uplink frame and the downlink frame terminate simultaneously.

43. A method of configuring wireless transmissions, substantially in accordance with any of the examples as described herein with reference to and illustrated by the accompanying drawings.

44. Apparatus for configuring wireless transmissions, substantially in accordance with any of the examples as described herein with reference to and illustrated by the accompanying drawings.

Application No:	GB1208098.2	**Examiner:**	Mr Jared Stokes
Claims searched:	1 to 44	**Date of search:**	30 August 2012

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-42	US2005/0047384 A1 (Wax et al.) See abstract, paragraphs 5 and 130
X	1-42	US2009/0268645 A1 (Chindapol et al.) See paragraph 2, paragraph 23 lines 6-10, paragraph 25 lines 1-5, paragraph 36 lines 1-5
X	1-42	Chang-Hwan Park et al., "A Synchronous Digital Duplexing Technique for Wireless Transmission in Indoor Environments", 2009 IEEE 69th Vehicular Tech. Conf., 26-29 April 2009
A	-	US2007/0248057 A1 (Keidar et al.) See paragraph 3
A	-	WO2010/040823 A1 (Ericsson) See page 3 lines 22-26, page 5 lines 12-17

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

H04W

The following online and other databases have been used in the preparation of this search report

EPODOC, INSPEC, WPI

International Classification:

Subclass	Subgroup	Valid From
H04W	0072/12	01/01/2009
H04W	0084/12	01/01/2009
H04W	0088/08	01/01/2009