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(54) **BAND STEERING WI-FI DIRECT CLIENT CONNECTIONS TO DUAL BAND WI-FI DIRECT AUTONOMOUS GROUP OWNER**

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(57) **ABSTRACT**

A band steering method and a system for a wireless network is disclosed. The network comprises a first and a second radio band, an access node, and a plurality of client devices having single or dual band capability. According to the method, the access node receives a probe request from one of said client devices on the first or second radio band. The probe request indicates whether the client device has single or dual band capability. Thereafter, a probe response is generated by the access node only if the probe request indicates that the client device has single band capability, or if the probe request indicates that the client device has dual band capability and the probe request is received by the access node on the second radio band. On receiving the probe response the client device can use the appropriate radio band for communications within the network.
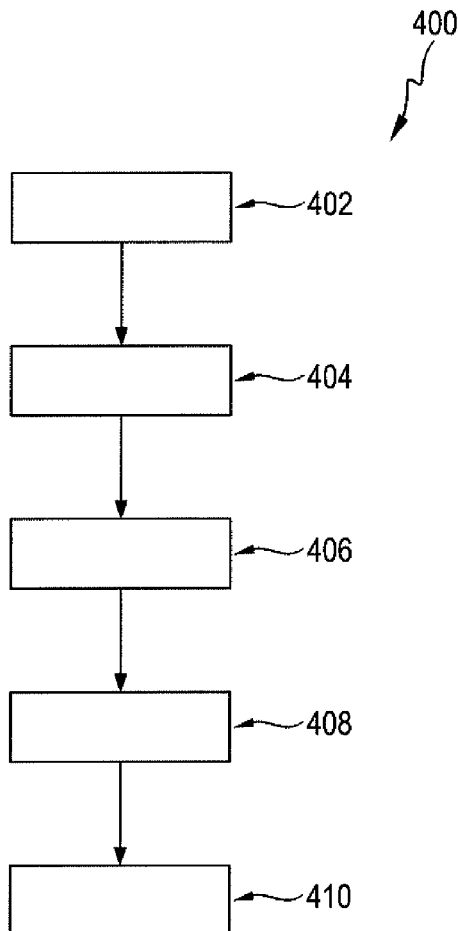
400

402

404

406

408

410

1000

114

116

104

106

102

110

110

110

112

110

112

112

112

108

108

108

100

Fig. 1

Fig. 2

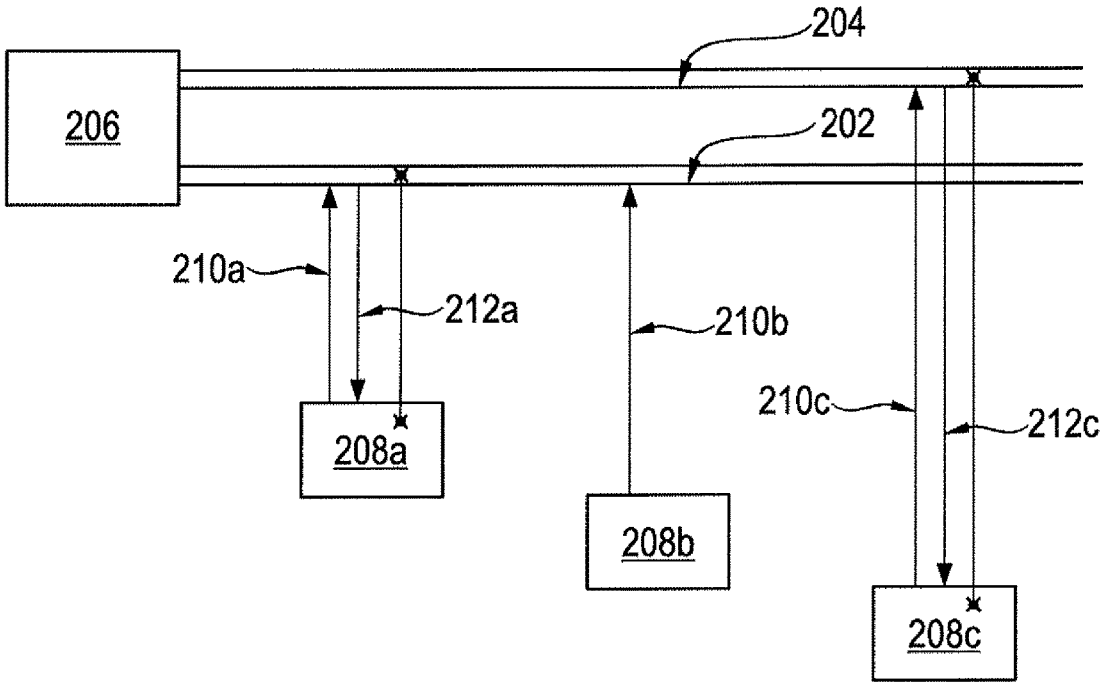304

306
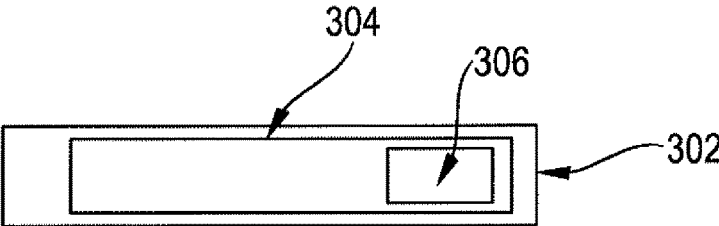
302
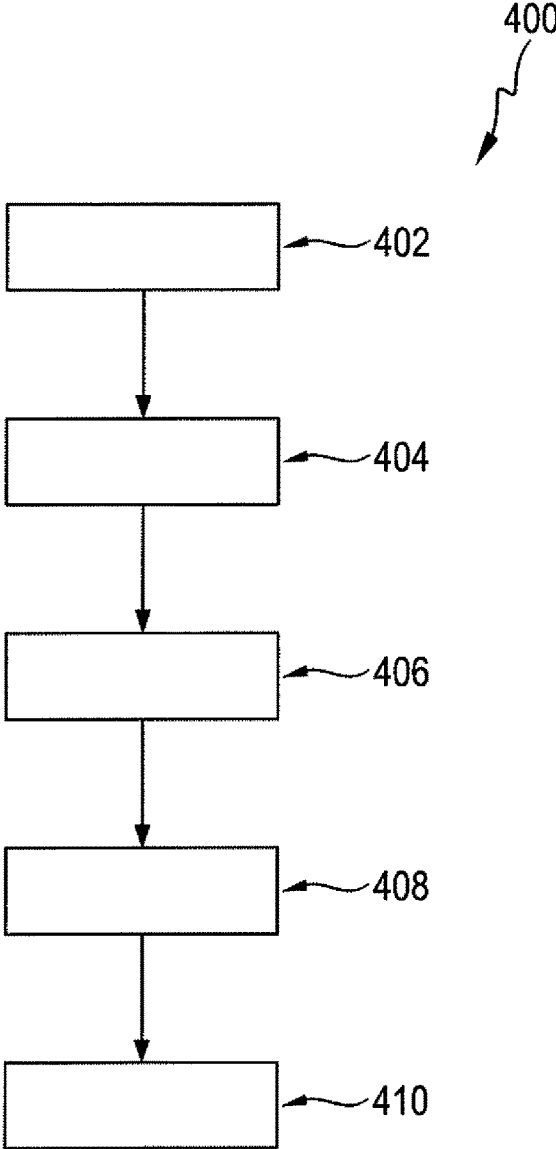
Fig. 3

400

402

404

406

408

410

Fig. 4

BAND STEERING WI-FI DIRECT CLIENT CONNECTIONS TO DUAL BAND WI-FI DIRECT AUTONOMOUS GROUP OWNER

TECHNICAL FIELD

[0001]   The present invention generally relates to a band steering method for a wireless network and a system for implementing the same. More particularly it relates to a band steering method and system for steering remote client devices to appropriate (Wi-Fi) radio bands or channels in a Wi-Fi Direct set up.

BACKGROUND OF THE INVENTION

[0002]   Wi-Fi Direct is a new technological advancement in Wi-Fi technology which aims to provide Peer-to-Peer connection between Wi-Fi devices and is also known as Wi-Fi Peer-to-Peer (P2P). In the earlier Wi-Fi technology, i.e. the legacy Wi-Fi Infrastructure network, the device is either supposed to play the role of a Wi-Fi station or a Wi-Fi Access Point. In legacy Infrastructure network a Station (STA) can connect to an access point (AP) but an STA cannot connect to an STA or an AP cannot connect to another AP. So if there are two devices that support the station role then they cannot connect to each other but require an AP in between to communicate with each other.

[0003]   Most of the modern day devices, for example smartphones, support STA feature by default and hence it is not possible to communicate with each other if they want to exchange any information. To bridge this gap a new topology called Wi-Fi Direct was introduced. Using Wi-Fi Direct topology many devices can form a group and transfer any kind of data with each other.

[0004]   In Wi-Fi Direct there are two ways in which a common group can be formed and peers in the group can exchange data. In the first method, the negotiation and group formation method, both the peer devices trying to communicate with each other play the role of a P2P Device. In order to connect to each other, they carry out a negotiation procedure during which one peer becomes a Group Owner and the other a Group Client. The Group Owner is synonymous to a legacy access point (AP), it is a beaconing entity. The Group Client is synonymous to a legacy station (STA). The Group Client connects to the Group Owner, thereafter several other client devices can also connect to the same Group Owner and become a part of the group.

[0005]   In the second method, the Autonomous Group Owner Role method, a Wi-Fi Direct client from the boot-up stage takes the role of a Group Owner, also known as Autonomous Group Owner (AGO). After initialization it starts beaconing. The other peer devices can discover this group owner and connect to it without going through the tedious Wi-Fi Direct negotiation procedure, as described in the first method.

[0006]   With the advancement in Wi-Fi chipset technology more and more semiconductor manufacturers are able to design and fabricate real dual band Wi-Fi chipsets. There is huge demand from various product manufacturers for such dual band Wi-Fi chipsets. With this advancement most of the modern Wi-Fi products have started supporting both the Wi-Fi ISM (industrial, scientific, and medical) bands, namely 2.4 GHz and 5 GHz. As a result of this advancement the Wi-Fi products that support both the Wi-Fi ISM bands are being majorly introduced into existing networks that previously only contained single band supporting Wi-Fi devices or remote client devices, i.e. only 2.4 GHz.

[0007]   Product manufacturers prefer that all Wi-Fi roles are supported, namely group client role and group owner role, in both the bands by the client devices so that all Wi-Fi features can be supported on both the bands. And thus all Wi-Fi features shall be available to both categories of remote devices, namely devices that support single band and devices that support dual band. Wi-Fi Direct or Wi-Fi Peer-to-Peer (P2P) role can be supported in both the Wi-Fi ISM Bands, namely 2.4 GHz and 5 GHz. Many original equipment manufacturers, especially Automotive OEMs, are demanding support for Wi-Fi Direct Autonomous Group Owner (AGO) role in both the bands on an Infotainment Head-Unit system. Therefore, dual band access nodes that support both the radio bands are found in most wireless networks these days.

[0008]   It is preferred to have a homogenous wireless network whereby the SSID, device name and security parameters for access nodes on both the bands is exactly the same and they appear as a single network to the wireless client devices. Due to this configuration a remote client device, which is dual-band capable, shall discover the access nodes on both the bands but due to the same discovery address (SSID) and device name of the access nodes only one is visible to the end user as a single network. This creates a problem. There is no standard way of controlling to which band of the access node the dual-band capable remote devices shall connect to.

[0009]   Every remote client device has its own algorithm for selecting which band of the access node to prefer for connection. So the dual band capable remote device can connect to the access node on the 2.4 GHz frequency channel or radio band of the network instead of connecting to the 5 GHz channel or (Wi-Fi) radio band. This is not at all desirable due to decreased performance and quality in terms of throughput for the end feature where these network devices are in use.

[0010]   It is preferable for client devices to use the 5 GHz band over the 2.4 GHz band as the 5 GHz band offers lower interference and higher throughput capabilities which guarantees better quality for any end feature that works on the wireless network. Hence it is always desirable that a dual-band capable remote client device always connects to a 5 GHz network rather than to a 2.4 GHz network.

[0011]   Another issue that arises when dual-band capable devices connect to the 2.4 GHz band is that of undesirable bandwidth sharing on the 2.4 GHz band of the access node in contrast to a complete wastage of bandwidth on the 5 GHz band of the access node. The 2.4 GHz band of the access node and the 5 GHz band of the access node have their own independent bandwidth to offer to their clients on a dual band chipset. But if the dual-band capable remote client devices as well as the single-band capable remote client devices all connect to the 2.4 GHz band of the access node then the bandwidth of 2.4 GHz band of the access node gets unnecessarily shared between many remote client devices resulting in bad quality and user experience whereas the bandwidth of the 5 GHz access node gets wasted due to no or very few connections.

[0012]   To address these problems a technique known as band steering is practiced that steers dual-band capable access nodes to the desirable 5 GHz radio band instead of the more congested 2.4 GHz radio band. But there exists no

standard, optimized and simple way of controlling to which band access node the dual-band capable remote devices shall connect to.

SUMMARY OF THE INVENTION

[0013] According to an embodiment, there is provided a band steering method and a system for a wireless network for steering remote client devices to appropriate (Wi-Fi) radio bands.

[0014] The network comprises a first and a second radio band, an access node, and a plurality of client devices. The client devices either have single or dual band capability. According to the method, the access node receives a probe request from one of said client devices on the first or second radio band. The probe request indicates whether the client device has single or dual band capability. Thereafter, a probe response is generated by the access node only if the probe request indicates that the client device has single band capability, or if the probe request indicates that the client device has dual band capability and the probe request is received by the access node on the second radio band. On receiving the probe response the client device can use the appropriate radio band for communications within the network.

[0015] In one of many embodiments the client device is a mobile phone, a tablet, a laptop, a hand held mobile platform unit or any other similar portable device.

[0016] Conventional systems use Media Access Control (MAC) addresses of the wireless client devices to prepare a machine-based classification pattern based on which band steering is implemented for new wireless client devices. In contrast to such systems, by using information residing in the probe request to band-steer wireless client devices into appropriate radio bands, there is no need for a prior classification or pattern to be prepared for new incoming wireless client devices. Therefore, a dynamic, speedy and an optimized band steering mechanism can be implemented using the method in accordance with the above embodiment.

[0017] In one embodiment, the probe request comprises a WPS information element. This WPS information element is related to the client device using Wi-Fi Protected Setup (WPS) Protocol. According to one embodiment, the network is a Wi-Fi Direct network and each client device has a corresponding WPS information element which indicates if the client device has single band or dual band capability. All Wi-Fi Direct devices use WPS (Wi-Fi Protected Setup) security protocol during connection. During the handshake process between the two devices trying to connect to each other, both devices indicate support and capability parameters of the WPS protocol by including this WPS information element consisting of many attributes in the various Wi-Fi management frames as defined by the standard specification. Probe-Request is also one of the management frames that is mandated to include this WPS information element. The advantage of using the WPS information element is that it is already available and can be readily made use of without having to rely on any previously prepared listing of MAC addresses for band steering of the client devices.

[0018] In one embodiment, the access node is located in an automotive infotainment head unit. The access node may be present in an automobile head unit. The head unit comprises a set of software and hardware units that together provide information as well as entertainment to the users. It can also

perform automotive control functions. Automotive infotainment systems have many wireless client devices simultaneously trying to establish a connection to be able to use the available radio bands. Having a band-steering mechanism as disclosed herein implemented for an automotive infotainment system that uses a head unit, the bandwidth utilization of the system can be regulated in a favorable manner and overcrowding of any one band can be avoided.

[0019] In one embodiment, the access node is a dual band Wi-Fi Direct or Wi-Fi Peer-to-Peer (P2P) Autonomous Group Owner. As an Autonomous Group Owner it starts beaconing and makes itself visible to the other peer or client devices. The other peer devices can discover this group owner and connect to it without going through a typically tedious ordinary Wi-Fi Direct negotiation procedure.

[0020] In another embodiment, the radio bands support Wi-Fi Direct or Wi-Fi P2P group owner role and Wi-Fi Direct or Wi-Fi P2P client role. By supporting all Wi-Fi roles in both the bands, namely group client role and group owner role, all Wi-Fi features can be supported on both the bands and all Wi-Fi features are available to both categories of remote devices, namely devices that support single band and devices that support dual band.

[0021] In an exemplary embodiment, the method is implemented by a Wi-Fi chipset firmware. In another embodiment, the method is implemented by a Wi-Fi driver. The advantage of implementing the method through Wi-Fi chipset firmware or Wi-Fi driver is that it provides flexibility as to updates or changes required by different users. Wi-Fi chipsets or drivers can be updated as and when new features and updates need to be added or installed into the systems where these drivers or chipsets are used for implementing the claimed method. Thereby, the possibility of future developments are not shut out from the system. In addition the chipset or drivers can be later integrated with different devices as desired by the user.

[0022] According to an embodiment, one of the attributes in the WPS information element is an RF band attribute which indicates if the device sending the WPS-IE in the management frame is a dual band device or a single band device. In an exemplary embodiment, dual band devices have this RF band attribute as "RF Bands: 2.4 and 5 GHz (0x03)" and single band devices have this attribute "RF Bands: 2.4 GHz (0x01)". The RF band attribute in the WPS information element is readily available and the information is easily readable. According to another embodiment, the WPS information element comprises Wi-Fi Protected Setup Protocol parameters.

[0023] In one embodiment, the first radio band is a 2.4 GHz industrial, scientific and medical (ISM) radio band and the second radio band is a 5 GHz ISM radio band.

[0024] According to an embodiment, a system is provided comprising a controller and a network. The network comprises an access node controlled by the controller, a first and a second radio bands and a plurality of client devices. The client devices either have single or dual band capability. The access node is arranged to receive a probe request from one of said client devices on the first or second radio band. The probe request indicates whether the client device has single or dual band capability. The access node is further arranged to generate a probe response only if the probe request indicates that the client device has single band capability, or if the probe request indicates that the client device has dual band capability, provided the probe request is received by

the access node on the second radio band in the second case. On receiving a probe response from the access node on either of the said two bands, in reply to its probe request, the client device can then use the appropriate radio band for communications within the network. This helps in effective steering of client devices to avoid over crowding of a specific radio band and thereby resulting in a balanced bandwidth usage amongst several client devices.

[0025] According to an embodiment the system further comprises a memory unit for storing a list of client devices found to be dual band capable. The controller may save in the memory unit the result of determination as to which of the client devices are single band capable client devices and/or which are dual band capable client devices. This list can be utilized in future to save time.

[0026] In accordance with another embodiment, there is provided a computer-program product having a non-transitory computer readable medium storing computer executable code which, when executed by computer, causes the above method to be performed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The present invention may be better understood from reading the following description of non-limiting embodiments, with reference to the attached drawings, wherein:

[0028] FIG. 1 schematically shows an example system in accordance with one of a number of embodiments;

[0029] FIG. 2 schematically shows another example system in accordance with one of a number of embodiments;

[0030] FIG. 3 schematically shows an example probe request in accordance with one of a number of embodiments; and

[0031] FIG. 4 is a flow chart for an example method in accordance with one of a number of embodiments.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0032] A typical Wi-Fi network consists of several remote client devices, radio channels or bands and access nodes on the radio bands. Wi-Fi Direct or Wi-Fi Peer-to-Peer (P2P) client devices or remote client devices discover the access nodes on a remote device by a standard Wi-Fi Direct discovery phase. During the discovery phase, the Wi-Fi Direct client devices send a probe request packets to the access node and the access node responds back with probe response packets. During this, the client devices scan all available Wi-Fi channels by transmitting probe request packets on the channels trying to connect to an access node on the wireless network. A dual band supporting client device would scan all 2.4 GHz and 5 GHz radio bands or channels whereas a single band client would scan only 2.4 GHz channels. A single band access node supports only a single band, for example either a 2.4 GHz band or a 5 GHz band, whereas a dual band access nodes supports both the radio bands.

[0033] A 5 GHz access node gets discovered in the scan phase on responding to the probe request on its 5 GHz operating channel. Similarly a 2.4 GHz access node gets discovered on responding to the probe request on its 2.4 GHz operating channel.

[0034] FIG. 1 shows an example system 1000 in accordance with one of a number of embodiments. The system

1000 comprises a network 100 and a controller 114. The network further comprises a dual band access node 106, which is controlled by the controller 114, radio bands 102, 104 available to the access node 106, and a plurality of client devices 108. These client devices 108 either have single band capability or dual band capability, i.e. the client devices 108 can communicate with the access node and/or each other through one or both of the radio bands 102, 104.

[0035] The system 1000 may include one or more Wi-Fi radio bands 102, 104. In an exemplary embodiment the system 1000 the network 100 includes two Wi-Fi radio bands, the first 102 radio band is a 2.4 GHz industrial, scientific and medical (ISM) radio band and the second 104 radio band is a 5 GHz ISM radio band. The system 1000 further includes one or more client devices 108 having either single band capability or dual band capability.

[0036] Each client device 108 may contain a transmitting unit (not shown in the figure) for transmitting a probe request 110 on the radio bands 102, 104 to the access node 106 for seeking to establish a connection through a radio band 102, 104 for communication purposes. The access nodes 106, 108 may play the role of a dual band Autonomous Group Owner in a Wi-Fi Direct (Wi-Fi Peer-to-Peer (P2P)) network having two radio bands or channels, namely 2.4 GHz. channel 102 and 5 GHz channel 104.

[0037] The controller 114 is in operable connection with the access node 106. The controller 100 determines whether the client device 102, 104 has single band capability or dual band capability from the content of the probe request 110 received by the access node 106. To determine this capability of the client devices 108, the controller 110 makes use of a WPS information element present in the probe request 110.

[0038] The WPS information element indicates if the client device 108 has single band capability or dual band capability. Single band capability indicates that the client device 108 is capable of communicating on the first radio band 102 and dual band capability means the client device 108 is capable of communicating on both the radio frequency bands 102, 104.

[0039] According to an embodiment as shown in FIG. 1, during a Wi-Fi Direct discovery phase, all client devices do a channel scan by sending probe requests 110 on the radio bands 102, 104 depending on their capabilities. For example, a single band capable client device 108 scans the first radio band 102, i.e. 2.4 GHz channel. The dual band remote device or the client device 108 which is capable of communicating on both the radio frequency bands 102, 104 initially does a full-channel scan by sending probe requests 110 on both radio bands 102, 104, i.e. 2.4 GHz and 5 GHz channels, and in turn receives probe responses 112 from the access node 106 on both the channels 102, 104, or the access node playing both the Autonomous Group Owner (AGO) roles.

[0040] Thus the dual band capable remote client device 108 discovers both the AGOs. But since both AGOs share a single discovery address (P2P-Device Address) and a single device-name, the remote client device 108 sees just one entry of the AGO. So this creates ambiguity and uncertainty as to which AGO (2.4 GHz or 5 GHz) does the remote client device 108 show to the end user and which AGO it connects to. Therefore, without implementation of a band steering

method there is a chance that the remote client device **108** can connect via the first radio band **102**, i.e. to the 2.4 GHz AGO which is not desirable.

[0041] On receiving a probe request **110** from the client device **108** on either of its bands **102**, **104**, the access node **106** may or may not generate a probe response **112** depending on certain conditions. The controller **114** controls the generation of the probe response **112** by the access nodes **106**. The control is so executed that a probe response **112** is only generated when the probe request **110** is received from a single band capable client device **108** or when the probe request **110** indicates that the client device **108** has dual band capability and the probe request **112** is received by the access node **106** on the second **104** radio band.

[0042] Therefore, a probe response **112** is found to be generated by the access node **106** in response to a probe request **110** received from a client device **108** when the probe request **110** is received by the access node **106** on the first **102** radio band, for example on the 2.4 GHz channel, from a device **108** with the WPS information element in the probe request **110** indicating single band capability. In a second situation, a probe response **112** is found to be generated when the probe request **110** is received by the access node **106** on a second **104** radio band, for example on the 5 GHz channel.

[0043] However, when a client device **108** sends a probe request **110** indicating dual band capability on a first band **102** of the access node **106**, the controller **114** prohibits the access node **106** from generating a probe response **112**. Due to a lack of probe response **112** from the access node **106**, the client device **108** having dual band capability is not able to connect on the first radio band **102**. In this way the controller **114** is able to steer the client device **108** having single band capability to the access node **106** on the first **102** radio band and the client device **108** having dual band capability to the access node **106** on the second **104** radio band in response to the probe response **112** sent by the access node **106** and subsequently received by the client devices **108**.

[0044] According to an embodiment of the system **1000** shown in FIG. **1** the controller **114** analyses the probe requests **110** received by the dual band access node **106** on both the bands **102**, **104**. The controller **114** reads the information carried by the probe request **110**. The information residing in the probe request **110** indicates if the client device **108** has single band capability or dual band capability.

[0045] The system **1000** further comprises a memory unit **116** connected with the controller **114**. The controller **114** may save in the memory unit **116** the result of determination as to which of the client devices **108** are single band capable client devices and which are dual band capable client devices. In an embodiment the memory unit **116** saves a list of dual band capable client devices for future use to save time. In another embodiment the memory unit **116** saves a list of single band capable client devices and a list of dual band capable client devices. The memory unit **120** may be implemented, for example, using a non-volatile memory such as a programmable read only memory (PROM) or an EPROM, and/or a volatile memory such as a DRAM, etc.

[0046] FIG. **2** shows another example system **2000** in accordance with one of a number of embodiments. FIG. **2** shows several connection attempts made by different client devices **208a**, **208b**, **208c**. According to FIG. **2**, the client

device **208a** sends a probe request **210a** to the first band **202** of the access node **106**. The probe request **210a** carries information indicating that the client device **208a** has single band capability. The access node **206** generates a probe response **212a** replying to the probe request **210a** received from the client device **208a**. The probe response **212a** is transmitted through the first band **202**. On receiving the probe response **212a** from the access node **206** on the first band **202**, the client device **208a** is now able to use the first band **202** for communications within the network.

[0047] Further, according to FIG. **2**, the client device **208b** sends a probe request **210b** to the first band **202** of the access node **106**. The probe request **210b** carries information indicating that the client device **208b** has dual band capability. The access node **206** does not generate a probe response to the probe request **210b** received from the client device **208b**. On receiving no probe response from the access node **206** on the first band **202**, the client device **208b** is not able to use the first band **202** for communications within the network.

[0048] In further operation of the system **2000** illustrated in FIG. **2**, the client device **208c** sends a probe request **210c** to the second band **204** of the access node **106**. The probe request **210c** carries information indicating that the client device **208c** has dual band capability. The access node **206** generates a probe response **212c** replying to the probe request **210c** received from the client device **208c**. The probe response **212c** is transmitted through the second band **204**. On receiving the probe response **212c** from the access node **206** on the second band **204**, the client device **208c** is now able to use the second band **204** for communications within the network. According to an embodiment all probe requests **210c** received on the second band **204** of the access node **206** receive a prompt probe response **212c** from the access node **206** for connection as it is understood that only a dual band capable device **208c** is capable of sending a probe request **210c** on the second band **204** of the access node **206**. Therefore, the information indicating dual band capability in the probe request **210c** may not even need to be read.

[0049] According to the system **2000** shown in FIG. **2**, the dual band capable client devices **208b**, **208c** are able to discover and subsequently connect via the access node **206** only on the second band **204** as the access node **206** is controlled to suppress the generation of a probe response when an attempt is made by the dual band capable client device **208b** to connect on the first band **202**. As a result, only the access node **206** on the second radio band **204**, i.e. the 5 GHz channel, is visible as an available access node **206** for connecting to the network, to the client devices **208b**, **208c** having dual band capability. In this way the less congested band, in this example the 5 GHz band **204**, is appropriately picked up by devices **208c** that are capable of supporting dual bands instead of the slower, first radio band **202**.

[0050] FIG. **3** depicts an exemplary probe request **302** signal and its constituents among one of a number of embodiments. All Wi-Fi Direct (Wi-Fi Peer-to-Peer (P2P)) devices use a security protocol called WPS (Wi-Fi Protected Setup) during connection. This protocol involves eight-way handshakes in which eight messages get exchanged between the two devices trying to establish a connection with each other. Both devices indicate support and capability parameters of the WPS protocol by including a WPS information element **304** consisting of many attributes in the various

Wi-Fi management frames as defined by the standard specification. The probe request **302** is also one of the management frames that are mandated to include the WPS information element **304**.

[0051] In one of many embodiments the probe request **302** carries a WPS information element **304** of the client device **108**. The client device **108** uses a Wi-Fi Protected Setup (WPS) Protocol, wherein the WPS information element **304**, residing in the probe request **302**, indicates if the client device **108** has single band capability or dual band capability.

[0052] According to one of many embodiments, one of the attributes in the WPS information element **304** is called an RF band attribute **306**. In other words, the WPS information element **304** of the client device **108**, carried in the probe request **302**, may further comprise an RF band attribute **306**. RF band attribute **306** may indicate if the client device **108** sending the WPS information element **304** in the management frame contained in the probe request **302** is a dual band capable device or a single band capable device.

[0053] In one exemplary embodiment, the dual band capable devices **208***b*, **208***c* shall have this attribute as: "RF Bands: 2.4 and 5 GHz (0x03)" and the single band capable devices **208***a* shall have this attribute as: "RF Bands: 2.4 GHz (0x01)".

[0054] The controller **114**, shown in FIG. **1**, makes use of the WPS information element **304**, shown in FIG. **3**, to determine which is a dual band capable client device **208***b*, **208***c* and which is a single band capable device **208***a* in the network **100** and take necessary actions based on that determination.

[0055] FIG. **4** is a flowchart illustrating a method **400** in accordance with one of many embodiments. The method **400**, as depicted in FIG. **4**, comprises a first step **402** of transmitting a probe request **110** by the client device **108** on one or more of the radio bands **102**, **104** available with the access node **106**. The second step **404** constitutes receiving the probe request **110** on one or more of radio bands **102**, **104** by the access node **106** capable of supporting both the radio bands **102**, **104**.

[0056] The next step **406** of the method **400** comprises determining whether the client device **108** sending the probe request **110** has single band capability or dual band capability. This determination is made from the information carried by the probe request **110**. This elements of information, residing in the probe request **110**, indicates if the client device **108** has single band capability or dual band capability.

[0057] The next step **408** comprises the generation or suppression of a probe response **112** by the access node **106**. In an embodiment of the method, three situations may arise. The first, where a probe request **110** is received on a first **102** radio band of the access node **106** from a client device **108** with the information in the probe request **110** indicating single band capability. The second, where a probe request **110** is received on a second **104** radio band from a client device **108**. The third, where a probe request **110** is received on a first **102** radio band from a client device **108** with the information in the probe request **110** indicating dual band capability.

[0058] According to the method **400**, a probe response **112** is generated by the access node **106** at all times when the first two enumerated situations take place. On the other hand, when the third situation takes place the access node **106**, **206** does not generate any probe response **212** in response to the probe request **110**, in other words the probe response **212** is suppressed.

[0059] Therefore, the probe response **112** is generated only when the probe request **110** is received by the access node **106** on a first **104** radio band from a device **108** with the probe request **110** indicating single band capability or when the probe request **110** is received by the access node **106** on a second **104** radio band. Whereas, there is no probe response generated in case of a dual band capable device **108** trying to connect to the first radio band **102** via the access node **206** on the first radio band **102**.

[0060] The next step **410** in the method **400** comprises steering the client device **108** having single band capability to the access node **106** on the first **102** radio band and the client device **108** having dual band capability to the access node **106** on the second **104** radio band based on the probe response **112** generated at the access node **106**.

[0061] These above steps ensure that a dual band capable client device **108** shall always be able to discover only the access node **106** on the second radio band **104**. For example, a dual band capable remote Wi-Fi Direct client device **108** shall be able to connect to the access node **106** on the 5 GHz channel **104** only and shall not be able to discover the access node **106** on the first radio band **102**, i.e. the 2.4 GHz channel **102**.

[0062] Whereas, a single band capable client device **108** shall be able to discover the first radio band **102**, for example, be able to connect to the access node **106** on the 2.4 GHz channel **102**.

[0063] Hence this method **400** ensures that these remote devices **108** can only initiate Wi-Fi Direct connections with the access nodes **108** on the radio bands **102**, **104** that they have discovered. Hence, according to an exemplary embodiment, a dual band capable client device **108** can initiate connection only with the 5 GHz autonomous group owner or access node **106** and a single band capable client device **108** can initiate connection only with the 2.4 GHz autonomous group owner or access node **106**. This ensures proper and efficient bandwidth sharing on both the bands **102**, **104**.

[0064] According to an exemplary embodiment of the system **1000**, in an extra ordinary situation when the second radio band or channel **104** is, for some reason, not available to the dual band capable devices **108**, an exception may be configured in the controller **114** which would enable the dual band capable devices **108** to discover the access node **106** on the first radio band **102** only after a certain period of time has elapsed since the dual band capable device **108** has started sending out probe requests **110** on the radio bands **102**, **104** attempting to seek a connection and has not been successful.

[0065] The description of embodiments has been presented for purposes of illustration and description. Suitable modifications and variations to the embodiments may be performed in light of the above without departing from the scope of protection as determined by the claims.

[0066] In particular, whilst some of the above examples are described in connection with Wi-Fi Direct networks, the embodiments disclosed herein may also be implemented in other wireless networks that require client devices to be channeled to a preferred band or network over another less preferred band or network.

1. A band steering method for a wireless network comprising at least first and second radio bands, at least one

access node, and a plurality of client devices, wherein the client devices either have single or dual band capability, the method comprising:

receiving, by the access node, a probe request from one of said client devices on the first or second radio band, wherein the probe request indicates whether the client device has single or dual band capability; and

generating, by the access node, a probe response only if:

(i) the probe request indicates that the client device has single band capability, or

(ii) the probe request indicates that the client device has dual band capability and the probe request is received by the access node on the second radio band; and

wherein the probe response is to cause the client device to use the first or second radio band for communications within the network.

2. The method according to claim 1, wherein the probe request comprises a WPS information element of the client device using Wi-Fi Protected Setup (WPS) Protocol, wherein the WPS information element indicates if the client device has single band or dual band capability.

3. The method according to claim 1, wherein the access node is located in an automotive infotainment head unit.

4. The method according to claim 1, wherein the access node is a dual band Wi-Fi Direct or Wi-Fi Peer-to-Peer (P2P) Autonomous Group Owner.

5. The method according to claim 1, wherein the client devices support Wi-Fi Direct or Wi-Fi Peer-to-Peer (P2P) group owner role and Wi-Fi Direct or Wi-Fi P2P client role.

6. The method according to claim 1, wherein the method is implemented by a Wi-Fi chipset firmware.

7. The method according to claim 1, wherein the method is implemented by a Wi-Fi driver.

8. The method according to claim 2, wherein the WPS information element comprises an RF band attribute.

9. The method according to claim 2, wherein the WPS information element comprises Wi-Fi Protected Setup Protocol parameters.

10. The method according to claim 1, wherein the first radio band is a 2.4 GHz industrial, scientific and medical (ISM) radio band and the second radio band is a 5 GHz ISM radio band.

11. A system comprising:

at least one controller;

a network, the network comprising:

at least one access node controlled by the controller;

at least a first and a second radio bands; and

a plurality of client devices, wherein the client devices either have single or dual band capability;

wherein the access node is arranged to

receive a probe request from one of said client devices on the first or second radio band, wherein the probe request indicates whether the client device has single or dual band capability; and

generate a probe response only if:

(i) the probe request indicates that the client device has single band capability, or

(ii) the probe request indicates that the client device has dual band capability and the probe request is received by the access node on the second radio band; and

wherein the probe request response is to cause the client device to use the first or second band for communications within the network.

12. The system according to claim 11, wherein the system further comprises a memory unit for storing a list of client devices found to be dual band capable.

13. The system according to claim 11, wherein the access node is a Wi-Fi Direct or Wi-Fi Peer-to-Peer (P2P) Autonomous Group Owner.

14. The system according to claim 11, wherein the access node is located in an automotive infotainment head unit.

15. An access node of a wireless network, the access node comprising:

a processor; and

a non-transitory computer readable medium storing instructions executable by the processor to:

receive, by the access node, a probe request from a client device on a first or second radio band, wherein the probe request indicates whether the client device has single or dual band capability; and

generating, by the access node, a probe response only if:

(i) the probe request indicates that the client device has single band capability, or

(ii) the probe request indicates that the client device has dual band capability and the probe request is received by the access node on the second radio band; and

wherein the probe response is to cause the client device to use the first or second radio band for communications within the wireless network.

16. The access node according to claim 15, wherein the probe request comprises a WPS information element of the client device using Wi-Fi Protected Setup (WPS) Protocol, wherein the WPS information element indicates if the client device has single band or dual band capability.

17. The access node according to claim 16, wherein the WPS information element comprises Wi-Fi Protected Setup Protocol parameters.

18. The access node according to claim 15, wherein the first radio band is a 2.4 GHz industrial, scientific and medical (ISM) radio band and the second radio band is a 5 GHz ISM radio band.

19. The access node according to claim 15, wherein the access node is located in an automotive infotainment head unit.

20. The access node according to claim 15, wherein the access node is a dual band Wi-Fi Direct or Wi-Fi Peer-to-Peer (P2P) Autonomous Group Owner.

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