US 20150085844A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2015/0085844 A1

(43) Pub. Date: Mar. 26, 2015

Tian et al.

(54) **ACCESS POINT COORDINATED RE-ASSOCIATION OF WIRELESS DEVICES**

(71) Applicant: **QUALCOMM Incorporated**, San Diego, CA (US)

(72) Inventors: **Qingjiang Tian**, San Diego, CA (US); **Yanjun Sun**, San Diego, CA (US); **Peerapol Tinnakornsrisuphap**, San Diego, CA (US)

(73) Assignee: **QUALCOMM Incorporated**, San Diego, CA (US)

(21) Appl. No.: **14/035,991**

(22) Filed: **Sep. 25, 2013**

Publication Classification

(51) **Int. Cl.**

H04W 48/16 (2006.01)

H04W 60/00 (2006.01)

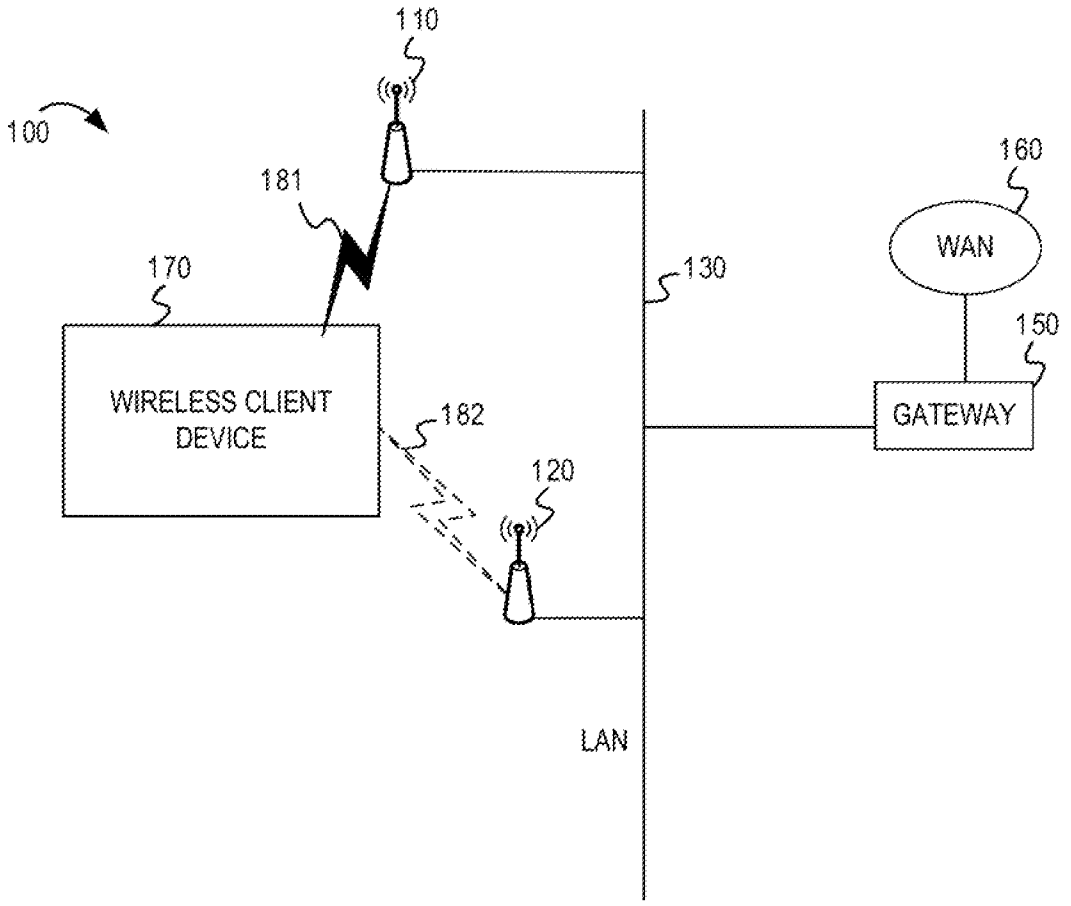
(52) **U.S. Cl.**

CPC ***H04W 48/16*** (2013.01); ***H04W 60/00*** (2013.01)

USPC **370/338**

(57) **ABSTRACT**

A first AP in a wireless network determines that a wireless client device should re-associate from the first AP to a second AP of the wireless network. The first AP communicates an AP coordination message from the first AP to the second AP to share coordination information with the second AP. The first AP coordinates with the second AP to cause the re-association of the wireless client device in accordance with the coordination information. The first and second AP may coordinate directly to synchronize re-association activities. Re-association activities may include the use of a configuration message to the wireless client device, managing transmit power of beacon messages from the first and second APs, or forced disassociation and blocking. The first AP may maintain a record of which re-association activity was successful in causing the wireless client device to re-associate to the second AP.



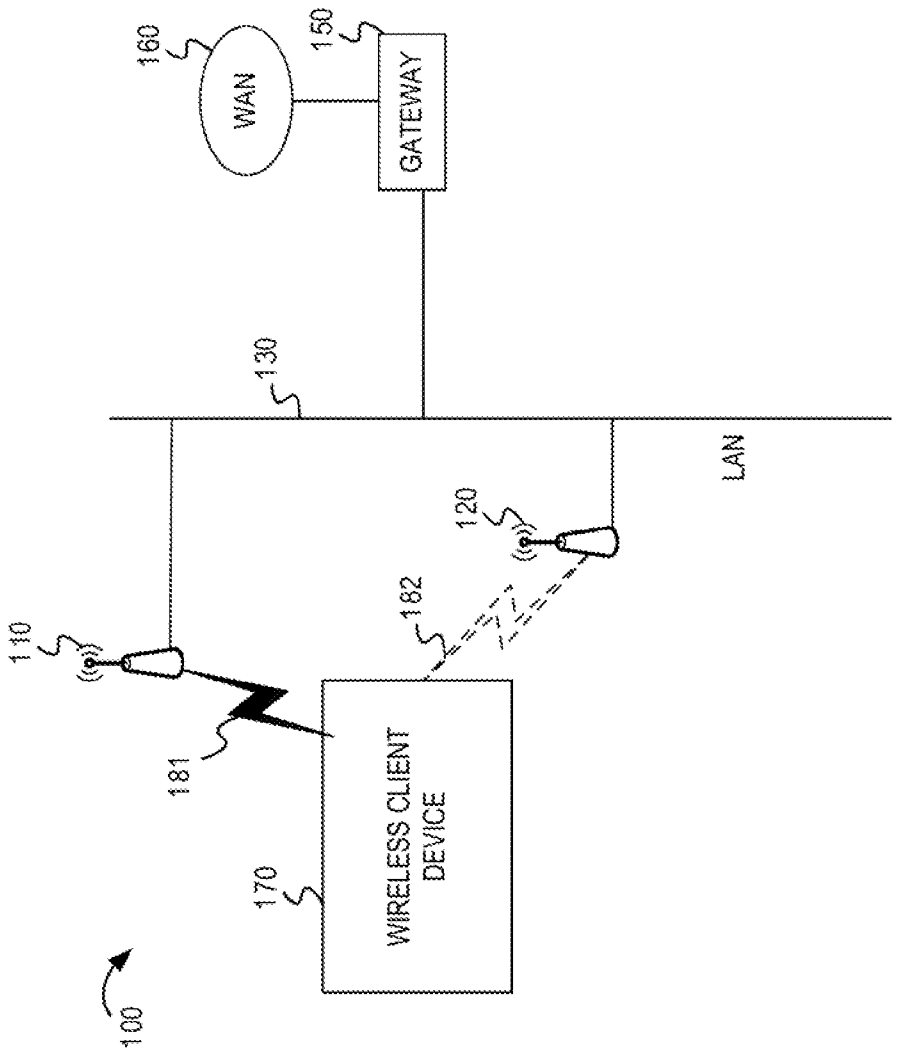

160
WAN
150
GATEWAY
130
LAN
120
182
110
181
WIRELESS CLIENT DEVICE
170
100

FIG. 1

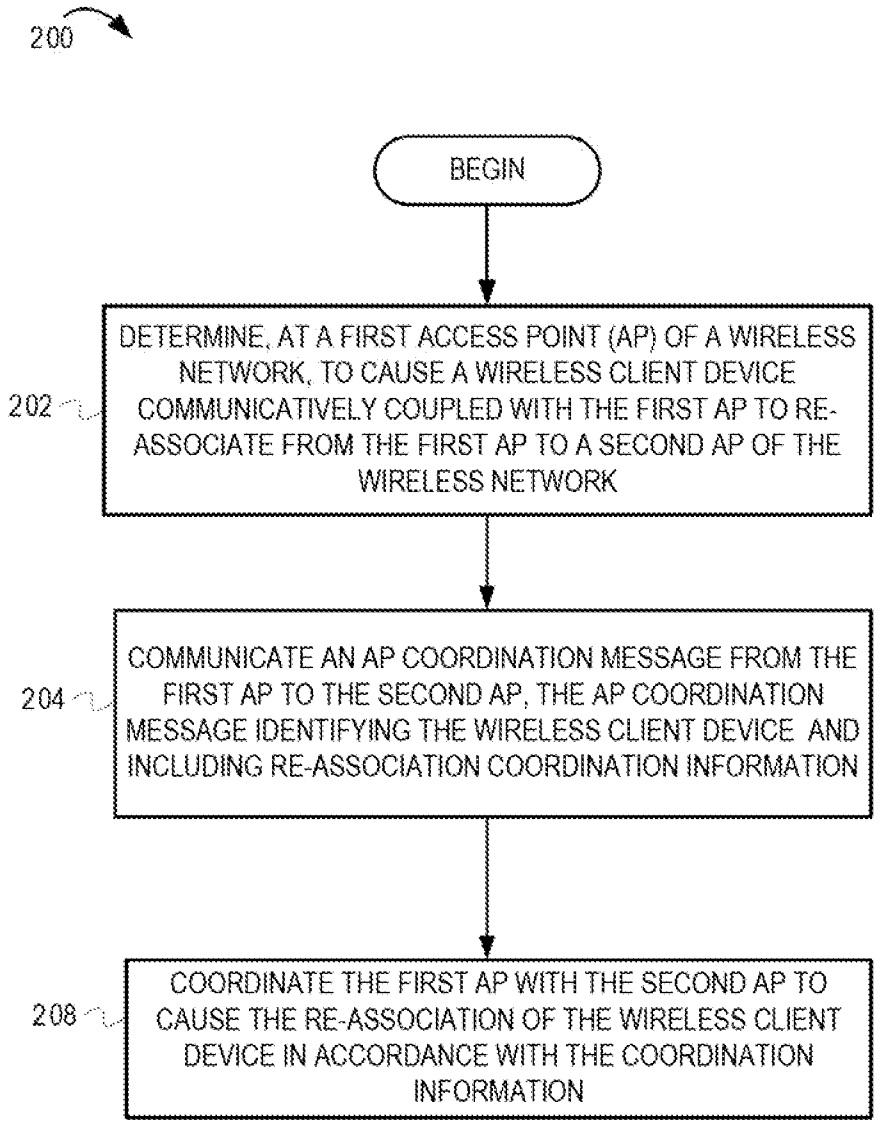

200
BEGIN
DETERMINE, AT A FIRST ACCESS POINT (AP) OF A WIRELESS NETWORK, TO CAUSE A WIRELESS CLIENT DEVICE COMMUNICATIVELY COUPLED WITH THE FIRST AP TO RE-ASSOCIATE FROM THE FIRST AP TO A SECOND AP OF THE WIRELESS NETWORK
202
COMMUNICATE AN AP COORDINATION MESSAGE FROM THE FIRST AP TO THE SECOND AP, THE AP COORDINATION MESSAGE IDENTIFYING THE WIRELESS CLIENT DEVICE AND INCLUDING RE-ASSOCIATION COORDINATION INFORMATION
204
COORDINATE THE FIRST AP WITH THE SECOND AP TO CAUSE THE RE-ASSOCIATION OF THE WIRELESS CLIENT DEVICE IN ACCORDANCE WITH THE COORDINATION INFORMATION
208

FIG. 2

TP Link Ex. 1009
Page 4

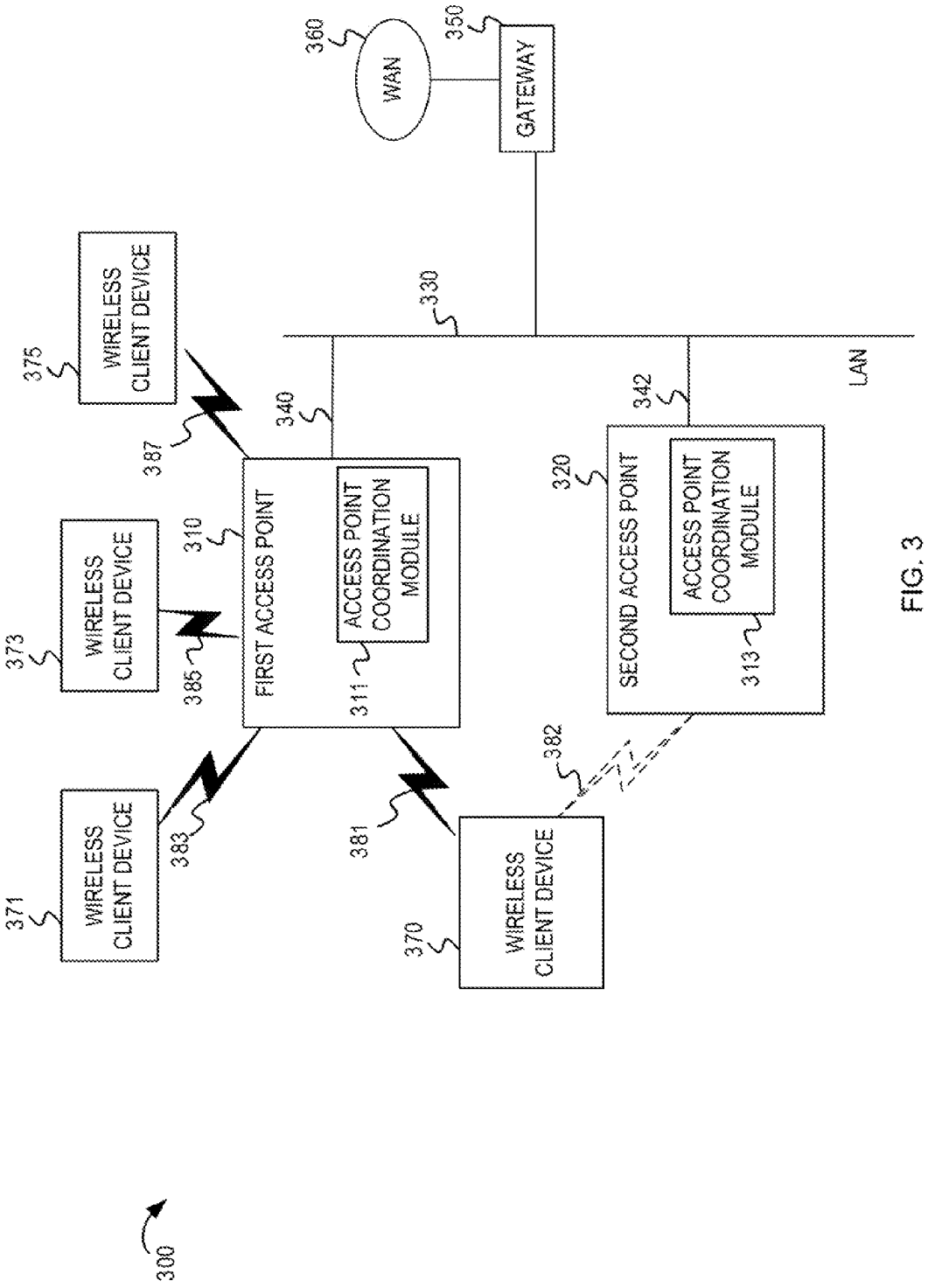


FIG. 3

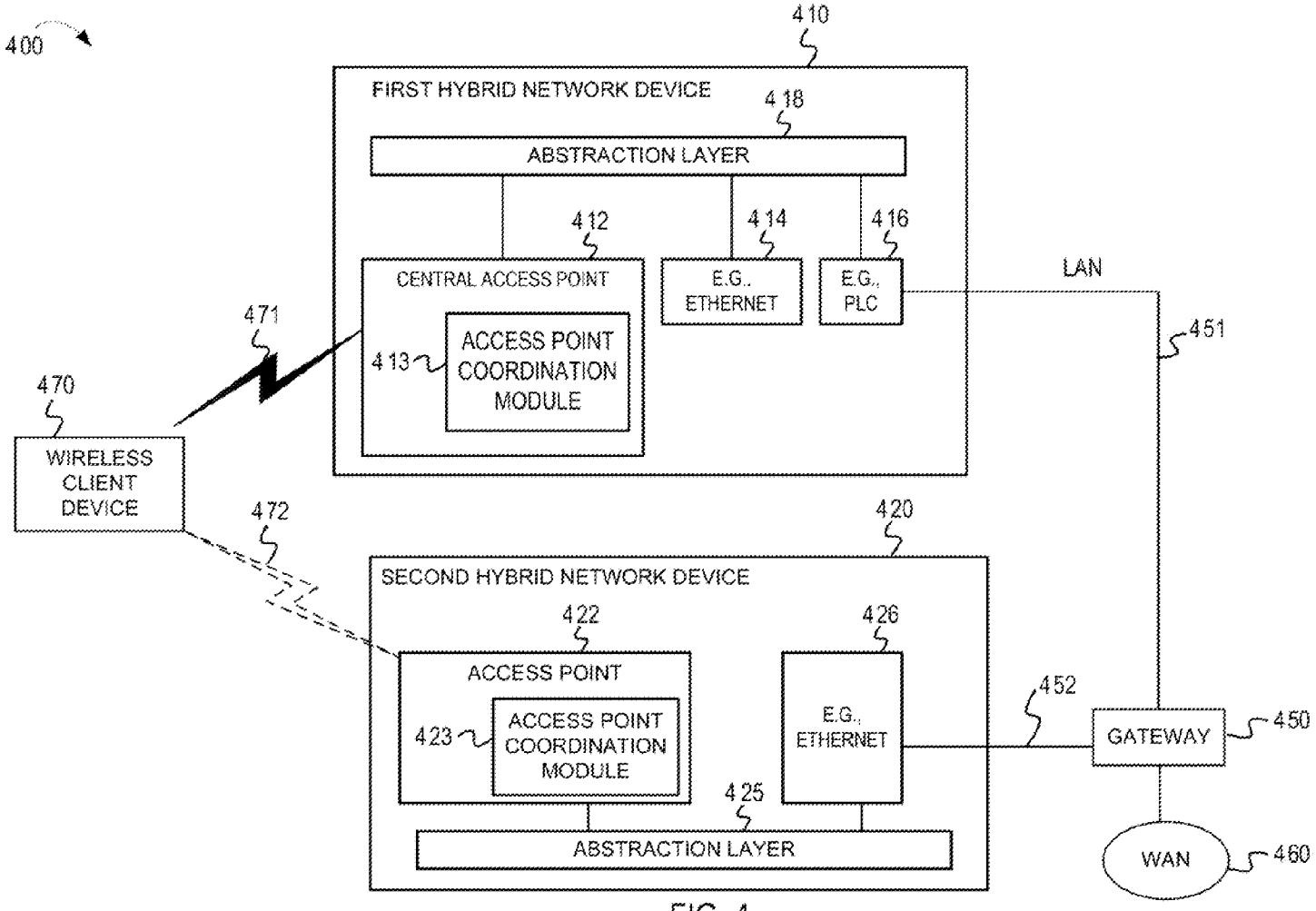

400
410
FIRST HYBRID NETWORK DEVICE
418
ABSTRACTION LAYER
412
414
416
CENTRAL ACCESS POINT
E.G., ETHERNET
E.G., PLC
LAN
471
413
ACCESS POINT COORDINATION MODULE
451
470
WIRELESS CLIENT DEVICE
472
420
SECOND HYBRID NETWORK DEVICE
422
426
ACCESS POINT
423
ACCESS POINT COORDINATION MODULE
E.G., ETHERNET
452
GATEWAY
450
425
ABSTRACTION LAYER
WAN
460

FIG. 4

TP Link Ex. 1009
Page 6

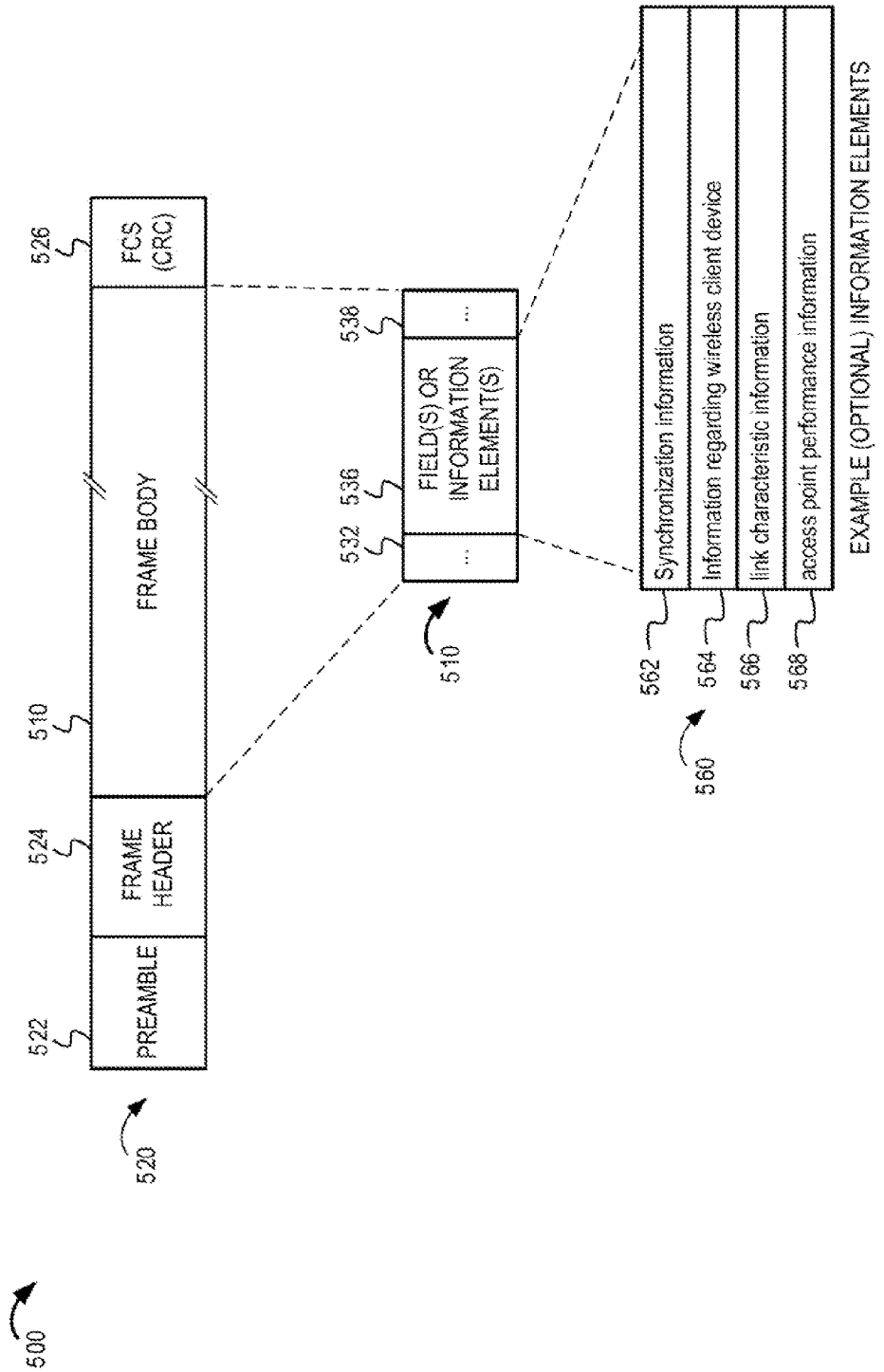


FIG. 5

TP Link Ex. 1009
Page 7

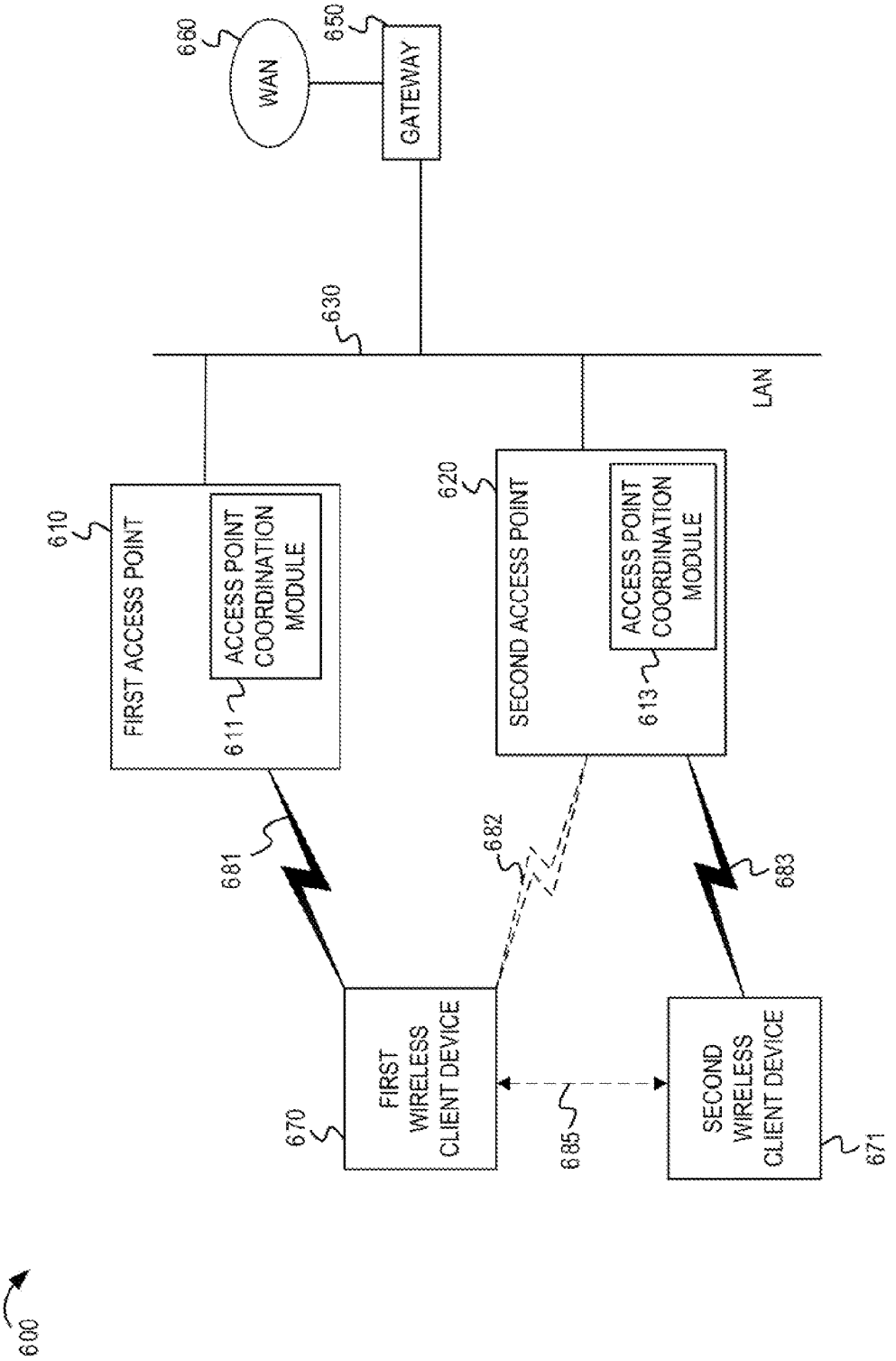


FIG. 6

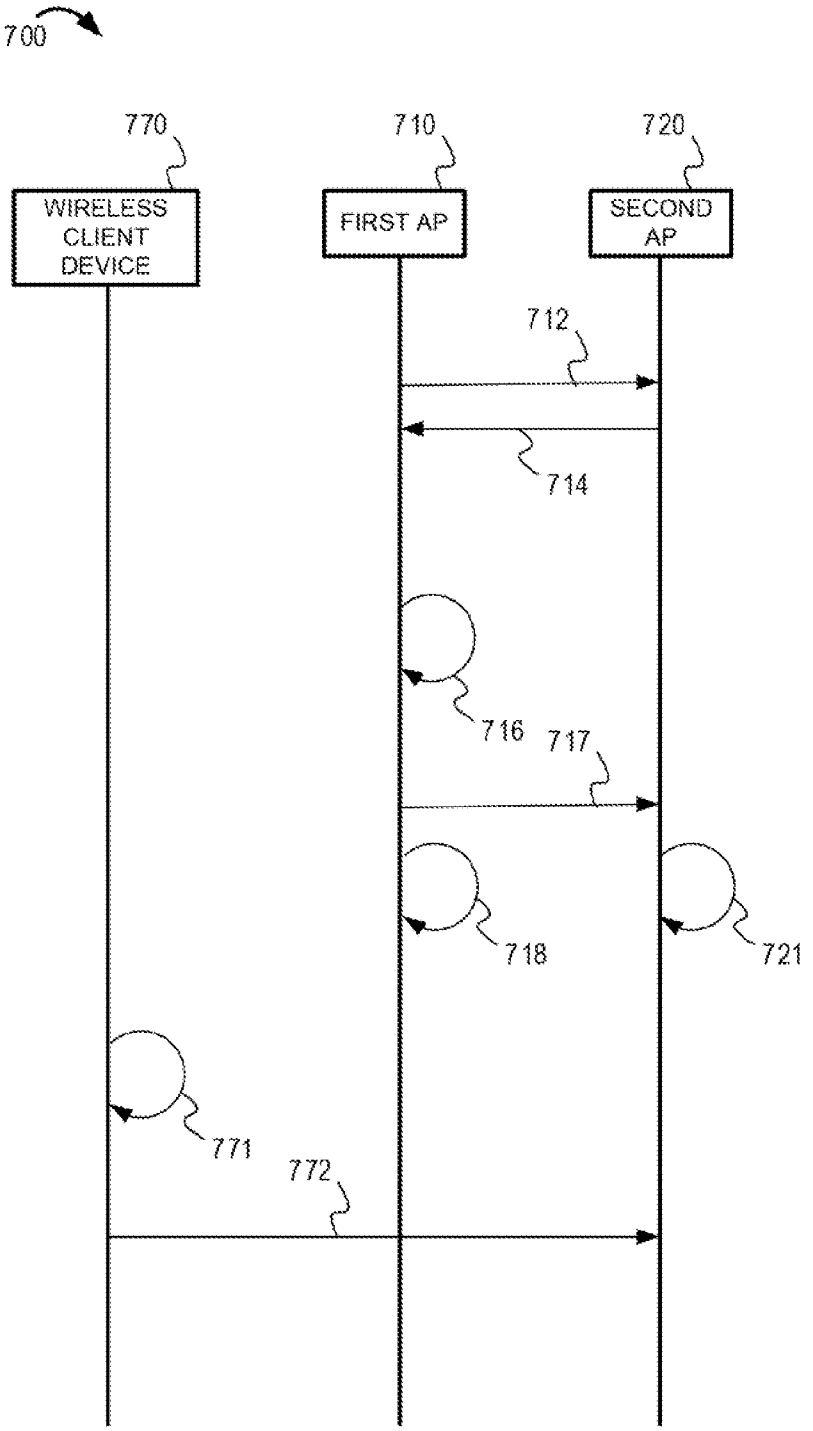

700
770
710
720
WIRELESS CLIENT DEVICE
FIRST AP
SECOND AP
712
714
716
717
718
721
771
772

FIG. 7

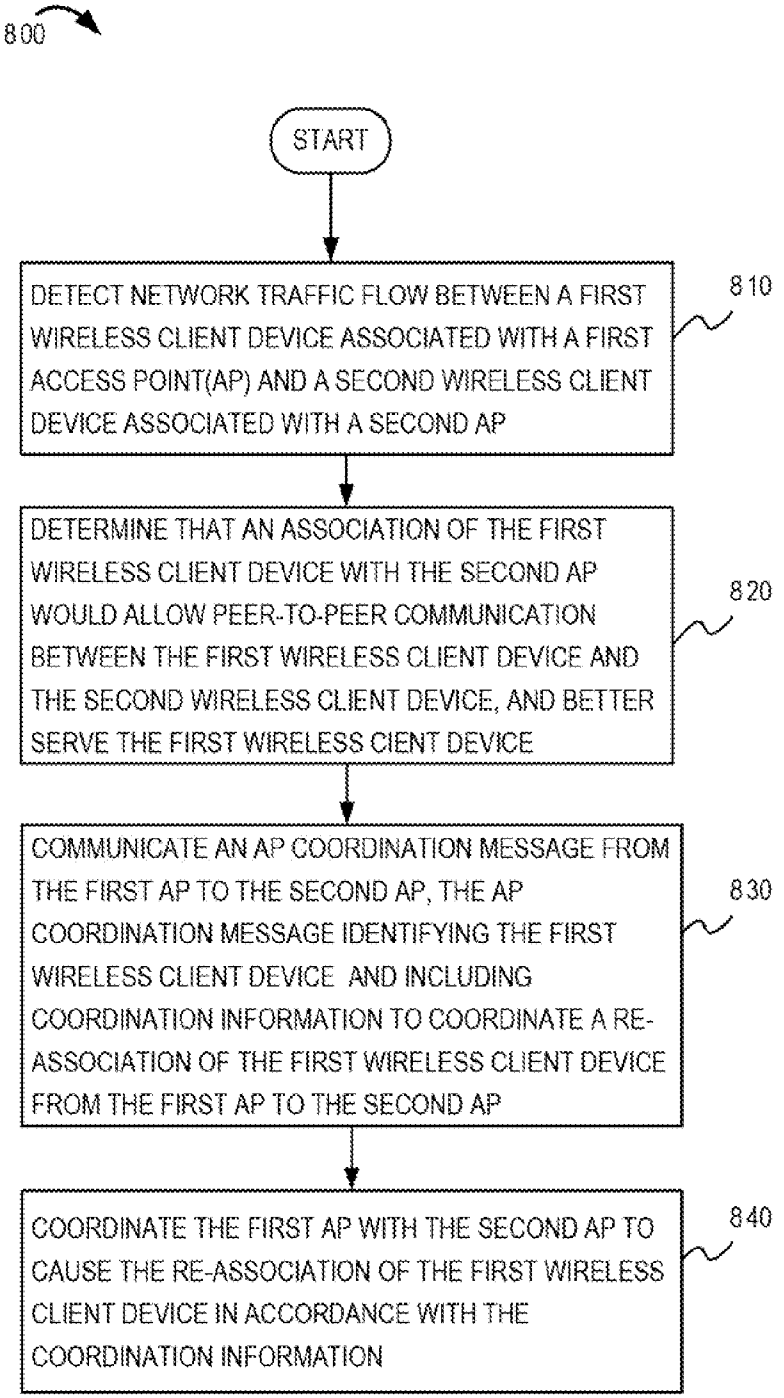

800
START
DETECT NETWORK TRAFFIC FLOW BETWEEN A FIRST WIRELESS CLIENT DEVICE ASSOCIATED WITH A FIRST ACCESS POINT(AP) AND A SECOND WIRELESS CLIENT DEVICE ASSOCIATED WITH A SECOND AP
810
DETERMINE THAT AN ASSOCIATION OF THE FIRST WIRELESS CLIENT DEVICE WITH THE SECOND AP WOULD ALLOW PEER-TO-PEER COMMUNICATION BETWEEN THE FIRST WIRELESS CLIENT DEVICE AND THE SECOND WIRELESS CLIENT DEVICE, AND BETTER SERVE THE FIRST WIRELESS CIENT DEVICE
820
COMMUNICATE AN AP COORDINATION MESSAGE FROM THE FIRST AP TO THE SECOND AP, THE AP COORDINATION MESSAGE IDENTIFYING THE FIRST WIRELESS CLIENT DEVICE AND INCLUDING COORDINATION INFORMATION TO COORDINATE A RE-ASSOCIATION OF THE FIRST WIRELESS CLIENT DEVICE FROM THE FIRST AP TO THE SECOND AP
830
COORDINATE THE FIRST AP WITH THE SECOND AP TO CAUSE THE RE-ASSOCIATION OF THE FIRST WIRELESS CLIENT DEVICE IN ACCORDANCE WITH THE COORDINATION INFORMATION
840

FIG. 8

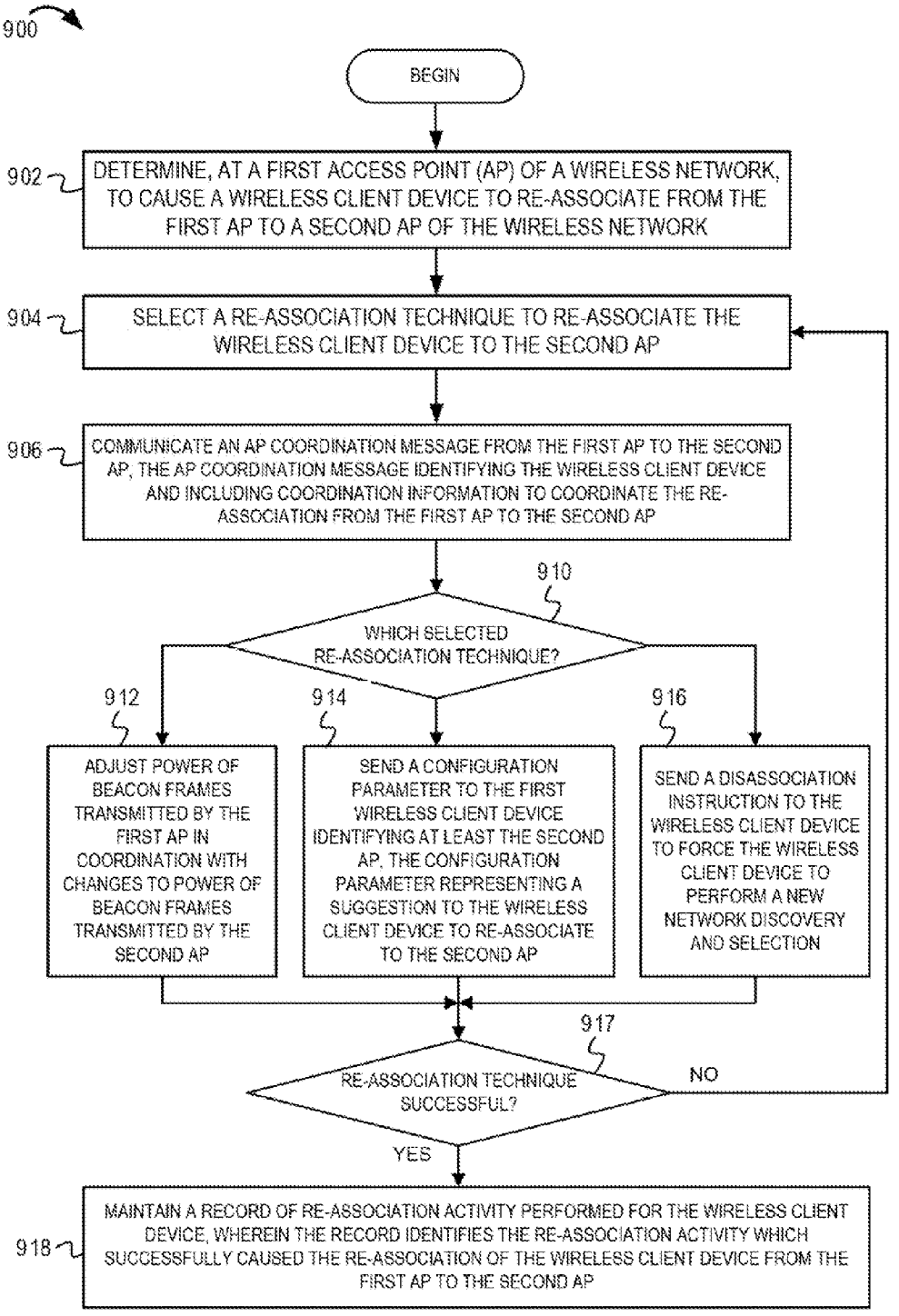

900
BEGIN
902
DETERMINE, AT A FIRST ACCESS POINT (AP) OF A WIRELESS NETWORK, TO CAUSE A WIRELESS CLIENT DEVICE TO RE-ASSOCIATE FROM THE FIRST AP TO A SECOND AP OF THE WIRELESS NETWORK
904
SELECT A RE-ASSOCIATION TECHNIQUE TO RE-ASSOCIATE THE WIRELESS CLIENT DEVICE TO THE SECOND AP
906
COMMUNICATE AN AP COORDINATION MESSAGE FROM THE FIRST AP TO THE SECOND AP, THE AP COORDINATION MESSAGE IDENTIFYING THE WIRELESS CLIENT DEVICE AND INCLUDING COORDINATION INFORMATION TO COORDINATE THE RE-ASSOCIATION FROM THE FIRST AP TO THE SECOND AP
910
WHICH SELECTED RE-ASSOCIATION TECHNIQUE?
912
ADJUST POWER OF BEACON FRAMES TRANSMITTED BY THE FIRST AP IN COORDINATION WITH CHANGES TO POWER OF BEACON FRAMES TRANSMITTED BY THE SECOND AP
914
SEND A CONFIGURATION PARAMETER TO THE FIRST WIRELESS CLIENT DEVICE IDENTIFYING AT LEAST THE SECOND AP, THE CONFIGURATION PARAMETER REPRESENTING A SUGGESTION TO THE WIRELESS CLIENT DEVICE TO RE-ASSOCIATE TO THE SECOND AP
916
SEND A DISASSOCIATION INSTRUCTION TO THE WIRELESS CLIENT DEVICE TO FORCE THE WIRELESS CLIENT DEVICE TO PERFORM A NEW NETWORK DISCOVERY AND SELECTION
917
RE-ASSOCIATION TECHNIQUE SUCCESSFUL?
NO
YES
918
MAINTAIN A RECORD OF RE-ASSOCIATION ACTIVITY PERFORMED FOR THE WIRELESS CLIENT DEVICE, WHEREIN THE RECORD IDENTIFIES THE RE-ASSOCIATION ACTIVITY WHICH SUCCESSFULLY CAUSED THE RE-ASSOCIATION OF THE WIRELESS CLIENT DEVICE FROM THE FIRST AP TO THE SECOND AP

FIG. 9

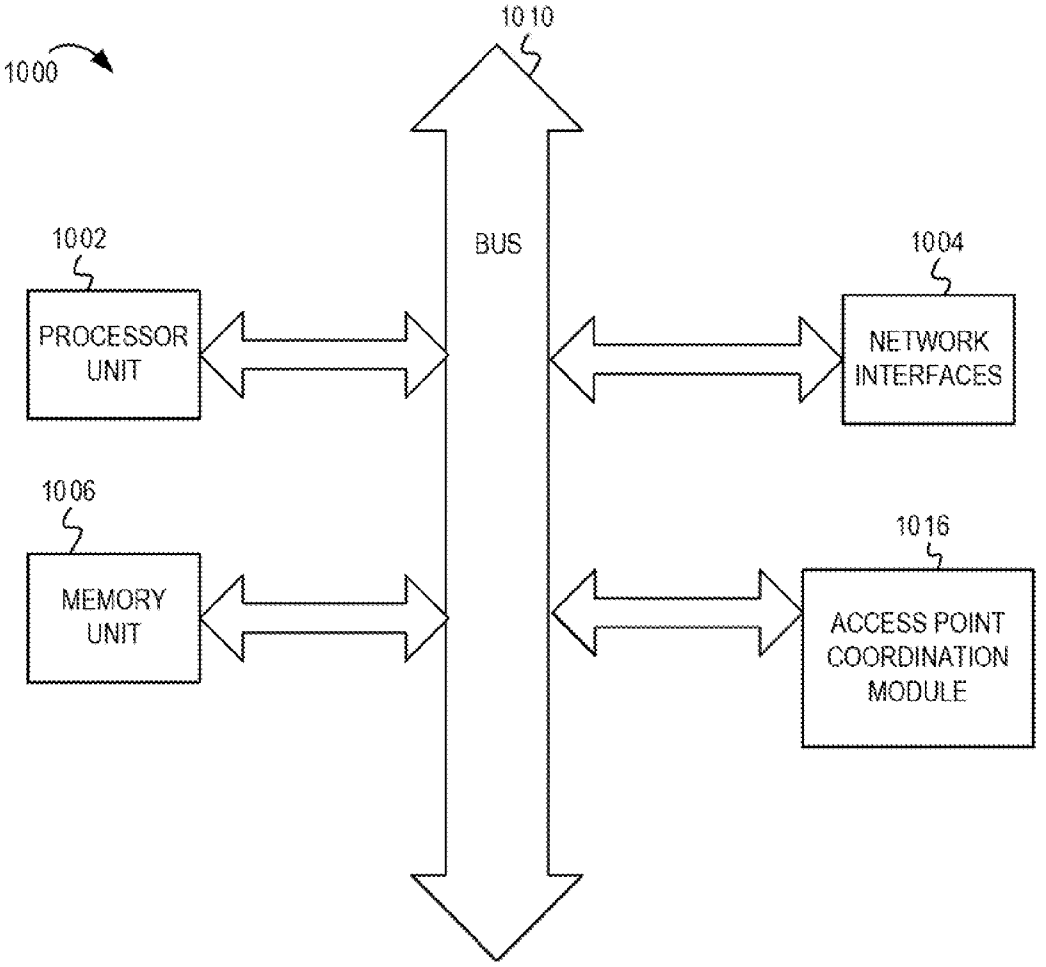

1000
1010
BUS
1002
PROCESSOR UNIT
1004
NETWORK INTERFACES
1006
MEMORY UNIT
1016
ACCESS POINT COORDINATION MODULE

FIG. 10

ACCESS POINT COORDINATED RE-ASSOCIATION OF WIRELESS DEVICES

BACKGROUND

[0001] Embodiments of the present disclosure generally relate to the field of communication networks, and, more particularly, to forced association of wireless client devices with a desired access point of a wireless network.

[0002] In a wireless network (e.g., a wireless local area network, or WLAN), a wireless client device (e.g., a wireless station, or STA) may establish a wireless association (i.e., "associate") with a wireless access point (AP). When a wireless network includes two or more APs, the wireless client device may select an AP using an AP selection algorithm at the wireless client device. However, the wireless client device may not be aware of backhaul conditions of the wireless network when choosing an AP. There may be many conditions known to one or more APs which may not be known to the wireless client device during selection of an AP.

[0003] Various network conditions may be relevant to selecting an AP to optimize performance characteristics (e.g., throughput, etc.). Hybrid communication networks typically comprise multiple networking technologies (e.g., wireless local area network (WLAN) technologies, powerline communication technologies, Ethernet, etc.) that may be interconnected using bridging-capable devices that forward packets between devices utilizing the different network technologies and media in order to form a single extended communication network. For example, in a hybrid communication network, each hybrid device may support multiple layer 2 interfaces using different access technologies (e.g., Ethernet, Wi-Fi, Coax, and Powerline) which can lead to varying conditions in the backhaul. Powerline communications (PLC) and Wi-Fi networks may be susceptible to noise from the environment, which may alter performance characteristics associated with a communications connection. Even though a wireless client device may initially chose an AP based upon signal strength, another AP may become a better choice as a result of changes to backhaul performance, loading, or user movement. Furthermore, each wireless client device may have different hardware capabilities (e.g., 2.4 GHz and/or 5 GHz support, dual band single radio, dual band dual concurrent radios, etc.). The IEEE 802.11 standards may define a Basic Services Set (BSS) transmission management mechanism to allow an AP to suggest that a wireless client device transition to a different AP. However, the wireless client device may choose to ignore the suggestion, or may not implement the capability.

SUMMARY

[0004] Various embodiments are disclosed to implement an access point coordinated re-association of a wireless client device in a wireless network. Prior to the access point coordinated re-association, the wireless client device may be wirelessly associated with a first AP. After the access point coordinated re-association, the wireless client device may be wirelessly associated with a second AP.

[0005] In one embodiment, a first AP determines to cause a wireless client device to re-associate to a second AP. An AP coordination message is communicated from the first AP to the second AP. The AP coordination message identifies the wireless client device and includes re-association coordination information. The first AP coordinates with the second AP to cause the re-association of the wireless client device in accordance with the re-association coordination information.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The present embodiments may be better understood, and numerous objects, features, and advantages made apparent to those skilled in the art by referencing the accompanying drawings.

[0007] FIG. **1** depicts an example system diagram of a wireless network.

[0008] FIG. **2** illustrates a flow diagram of example operations to implement a re-association of a wireless client device from a first AP to a second AP of a wireless network.

[0009] FIG. **3** depicts an example conceptual diagram for detecting network conditions in a wireless network to cause a wireless client device to re-associate from a first AP to a second AP of a wireless network.

[0010] FIG. **4** depicts an example system diagram to cause a wireless client device to re-associate from a first AP to a second AP of a hybrid network based on backhaul conditions.

[0011] FIG. **5** depicts an example conceptual diagram of an AP coordination message sent from a first AP to a second AP of a wireless network.

[0012] FIG. **6** depicts an example conceptual diagram of a re-association of a first wireless client device from a first AP to a second AP based on detecting network traffic flow between the first wireless client device and a second wireless client device associated with the second AP.

[0013] FIG. **7** depicts an example sequence diagram of message exchanges between a wireless client device, a first AP, and a second AP to cause the wireless client device to re-associate from the first AP to the second AP in a wireless network.

[0014] FIG. **8** illustrates a flow diagram of example operations to cause a first wireless client device to re-associate from a first AP to a second AP based on detecting network traffic between the first wireless client device and a second wireless client device associated with the second AP.

[0015] FIG. **9** illustrates a flow diagram of example operations to cause a first wireless client device to re-associate from a first AP to a second AP by utilizing one of a plurality of techniques stored in a network memory of a wireless network.

[0016] FIG. **10** is an example block diagram of one embodiment of an electronic device capable of implementing various embodiments in accordance with this disclosure.

DESCRIPTION OF EMBODIMENT(S)

[0017] The description that follows includes exemplary systems, methods, techniques, instruction sequences and computer program products that embody techniques of the present disclosure. However, it is understood that the described embodiments may be practiced without these specific details. For instance, although examples refer to re-associating (which may also be referred to as transiting, switching, moving, repositioning, handing over, etc.) a single wireless client device from a first AP to a second AP, embodiments are not so limited. In some embodiments, the first and second APs may coordinate to re-associate a plurality of wireless client devices from the first AP to the second AP or amongst a plurality of APs. In other instances, well-known instruction instances, protocols, structures and techniques have not been shown in detail in order not to obfuscate the description.

[0018] A wireless client device may be communicatively coupled (e.g., wirelessly associated or having a wireless association in accordance with an association protocol) with a first AP of a wireless network. The first AP may have access to more information regarding backhaul conditions or other available access points than is available to the wireless client device. For example, the first AP and a second AP may exchange information (either directly or through a central controller) regarding network conditions determined by each of the first and second APs. In accordance with this disclosure, the first AP may determine to re-associate (which may also be referred to as move, transfer, relocate, transition, switch, re-position, handover, or the like) the wireless client device from the first AP to the second AP of the wireless network. The first AP may determine that a re-association should occur based on a variety of factors including, but not limited to, backhaul capacity, wireless resource utilization, peer-to-peer communication, or the like.

[0019] In this disclosure, a re-association of the wireless client device refers to a change in the wireless association of the wireless client device from a first AP to a second AP. Prior to a re-association, the wireless client device may be wirelessly associated with the first AP. After the re-association, the wireless client device may be wirelessly associated with the second AP. In some embodiments, re-association may also involve the exchange of association protocol messages between the wireless client device and the second AP. Re-association does not necessarily involve physical or geographic movement of the wireless client device.

[0020] There are several ways in which a re-association could be performed in a wireless network. It should be noted that a re-association does not necessarily involve any messages from the first AP to the client device, such as a handover or handoff message to a wireless client device. In many examples described herein, the first and second APs manage the wireless environment such that the wireless client device independently performs a client-side AP selection that effectively results in a re-association of the wireless client device from the first AP to the second AP.

[0021] The APs may coordinate re-association activities to cause the wireless client device to re-associate from the first AP to the second AP. The first and second APs may coordinate re-association activities to cause the wireless client device to perform client-side AP selection of the second AP which effectively results in the desired re-association. Furthermore, the first AP and/or the second AP may maintain a history of which re-association activities are supported and/or effective for particular client devices as well as latency associated with previous re-associations. The latency information may indicate an amount of time between beginning of a previous re-association activity and a completion of the previous re-association activity.

[0022] FIG. **1** depicts an example system diagram that includes a wireless network **100**. The wireless network **100** includes a wireless client device **170** (e.g., a laptop, computer, sensor, camera, thermostat, mobile station, wireless device, a smartphone, etc.), a first AP **110**, and a second AP **120**. The wireless network **100** may be served by a local area network (LAN) backhaul **130**. The LAN backhaul **130** may be communicatively coupled to a wide area network (WAN) **160** via a gateway **150**. Initially in FIG. **1**, the wireless client device **170** is associated with the first AP **110** via a first wireless link **181**. In this document, terms such as wireless link, wireless connection, wireless association, or the like, may be used interchangeably to refer to a wireless communications relationship between two devices.

[0023] In some examples, coordination between the first AP and the second AP may assist in the identification of conditions in which the wireless client device would be better served in the wireless network by having the wireless client device re-associate from the first AP to the second AP. The first and second APs **110**, **120** may exchange information to determine whether the wireless client device **170** would be better served by the second AP **120**. For example, the APs **110**, **120** may exchange information about network traffic flow, backhaul network conditions, or network bandwidth availability. The APs **110**, **120** may exchange information regarding wireless capacity to serve the wireless client device **170** or the number of wireless client devices associated with the each AP (as described below in FIG. **3**). When the backhaul conditions support greater throughput for the wireless client device via the second AP **120** (rather than the first AP **110**), a re-association of the wireless client device from the first AP **110** to the second AP **120** may be initiated. Similarly, when the first AP **110** is overloaded (e.g., being associated with a large number of wireless client devices), the first AP **110** and the second AP **120** may coordinate to re-associate the wireless client device to the second AP **120**. In some embodiments, the APs **110**, **120** may exchange information about application throughput, such as throughput capable from each of the APs **110**, **120** to an application server (such as, without limitation, a resource via the WAN **160**). For example, the second AP **120** may offer greater application throughput (via the LAN backhaul **130** to the WAN **160**) to the wireless client device **170** than the application throughput offered by the first AP **110**.

[0024] The APs **110**, **120** may also exchange information (as described below in FIG. **6**) about any existing network traffic between the wireless client device **170** and one or more other wireless client devices associated with the second AP **120**. Based on information exchanged with another AP, the first AP **110** may determine that the wireless client device **170** should re-associate to the second AP **120**. For example, when a first wireless client device (such as wireless client device **170**) is directing traffic primarily to a second wireless client device (not shown) associated with the second AP **120**, it may be desirable to cause the first wireless client device to re-associate to the second AP **120**. In some implementations, the APs **110**, **120** may consolidate a plurality of wireless client devices to re-associate with the same AP then they may engage in direct peer-to-peer communications. By coordinating re-association activities between the first and second APs, the peer wireless client devices can be associated to the same access point. Coordination between the first and second APs may prevent the peer wireless client devices from re-associating from the first AP to the second AP if the peer wireless client devices are already associated with the same first AP. As such, the first AP and second AP may share information to increase the likelihood that devices with peer-to-peer traffic are associated with the same access point.

[0025] Upon determining to cause the re-association of wireless client device **170** from the first AP **110** to the second AP **120**, the first AP **110** may communicate an AP coordination message (as described below in FIG. **5**) to the second AP **120**. The AP coordination message may include information about the wireless client device **170** (e.g., an identifier or other information regarding the wireless client device **170**) and one or more instructions for coordinating re-association activities

at the second AP **120**. It is noted that in some implementations, the AP coordination message may be exchanged directly between the wireless access points (such as APs **110**, **120**) of the wireless network. In other implementations, the APs may coordinate by communicating via a central controller. In other implementations, one of the APs may be designated a master AP or a centralized AP for purposes of coordinating re-association activities among a group of APs.

[0026] This disclosure includes several re-association activities which may be used by the APs to cause a re-association of a wireless client device from a first AP to a second AP. Not all re-association activities (also referred to as re-association techniques or procedures) are supported by each wireless client device. For example, in IEEE 802.11v or other protocols, the first AP may simply ask the wireless client device to re-associate to the second AP. An IEEE 802.11v configuration message may include a list of one or more other APs (for example, including the second AP) as a suggestion to the wireless client device to re-associate to another AP. But if the wireless client device does not support IEEE 802.11v protocols or chooses to ignore the suggestion, the re-association may not occur. Another re-association activity may include network-side operations, such as the first AP forcing a hard disconnect of the wireless client device. The first AP may block traffic (at least one incoming packet) for the wireless client device to cause the wireless client device to select another AP. In yet another re-association activity, the first AP may reduce power of a beacon transmission such that the wireless client device may perceive reduced signal strength associated with the first AP and independently select the second AP.

[0027] In several of the re-association activities described in this disclosure, the success of the re-association activity may be improved by coordinating re-association activities of the first AP with re-association activities of the second AP. For example, in the example where the first AP reduces power of the beacon transmission, it may be possible for the second AP to concurrently increase power of beacon transmissions from the second AP to further stimulate the wireless client device to select the second AP. In some implementations, the first and second AP may coordinate power levels of beacon frames while forcibly disassociating the wireless client device from the first AP to cause the wireless client device to select the second AP based on signal strength metrics.

[0028] Returning to FIG. **1**, the first AP **110** and the second AP **120** may coordinate to re-associate the wireless client device **170** from the first AP **110** to the second AP **120**. Upon completion of the re-association, the wireless client device **170** may no longer have the first wireless link **181** with the first AP **110**, but rather will have a second wireless link **182** between the wireless client device **170** and the second AP **120**. The re-association may include the wireless client device **170** performing a network re-selection process (e.g., scan and association) that results in the second wireless link **182** instead of the first wireless link **181**. As described previously, there may be several techniques or re-association activities which the first AP **110** and second AP **120** may perform concurrently to cause the wireless client device **170** to select the second AP **120** rather than the first AP **110**.

[0029] In some embodiments, a record of previous re-association activities for the wireless client device may be maintained at a network memory to identify the previous re-association activities that successfully caused the re-association of the wireless client device **170** from the first AP **110** to the second AP **120**. In some implementations, a latency associated with a previous re-association activity may be stored with the history of the previous re-association activity. For example, the first AP **110** may record the latency from initiating a particular re-association technique until receiving confirmation from the second AP **120** that the wireless client device **170** has completed the re-association. The first AP **110** may determine, for example, that a wireless client device **170** supports more than one re-association technique and may select a particular re-association technique which is associated with a lower average latency based on previous uses of the particular re-association technique.

[0030] In some implementations, one or both of the first AP **110** and the second AP **120** may store the information about previous re-association operations in their respective memories. In other implementations, the first AP **110** and/or the second AP **120** may store the information about the re-association operations at a central AP of the wireless network **100**. The first AP **110** and/or the second AP **120** can utilize information regarding the history of previous re-association operations for the wireless client device **170** to determine a set of operations to be performed in a subsequent re-association of the wireless client device **170** (as described below in FIG. **9**).

[0031] FIG. **2** illustrates a flow diagram **200** of example operations resulting in a re-association of a wireless client device from a first AP to a second AP of a wireless network.

[0032] At block **202**, it is determined, at a first AP of a wireless network, to cause a wireless client device to re-associate from the first AP to a second AP of the wireless network. The first AP may determine to cause the wireless client device to re-associate to the second AP based, at least in part, upon backhaul capacity, wireless resource utilization, peer-to-peer communication, or other conditions.

[0033] At block **204**, an AP coordination message is communicated from the first AP to the second AP. The AP coordination message identifies the wireless client device and includes coordination information to coordinate the re-association from the first AP to the second AP. In one implementation, the AP coordination information includes a device identifier of the wireless client device. The AP coordination message may also include timing information or other coordination information regarding a selected re-association activity that will be performed by the first AP to cause the wireless client device to re-associate to the second AP.

[0034] At block **208**, the first AP coordinates with the second AP to cause the re-association of the wireless client device in accordance with the coordination information. For example, the first AP may instruct the second AP to temporarily increase the transmit power of the beacon frames transmitted from the second AP. In some embodiments, the first AP may reduce the transmit power of the beacon frames transmitted from the first AP. The first AP may cause a disassociation of the wireless client device, prompting the wireless client device to rescan for available APs. On detecting beacon frames with greater power (e.g., greater received signal strength indicator (RSSI)) from the second AP, the wireless client device may associate with the second AP, effectively resulting in re-association from the first AP to the second AP. By coordinating re-association activities, the first AP and second AP may cause a legacy wireless client device to select the appropriate AP without specific re-association commands to the legacy wireless client device. Furthermore, timing information may be used to synchronize re-association activi-

ties among APs so that transmit power adjustments or other re-association activities can be performed temporarily and concurrently.

[0035] FIG. **3** depicts an example conceptual diagram for detecting network conditions in a wireless network to re-associate a wireless client device from a first AP **310** to a second AP **320** of a wireless network **300**, similar to the corresponding features of FIG. **1**. The wireless network **300** may include a first AP **310** having a first AP coordination module **311**, a second AP **320** having a second AP coordination module **313**, and wireless client devices **370**, **371**, **373**, **375**. The APs **310**, **320** may be similar to the APs **110**, **120**, respectively. Similarly, the wireless client devices **370**, **371**, **373**, **375** may be similar to the wireless client device **170**. In FIG. **3**, the wireless client devices **370**, **371**, **373**, and **375** are associated with the first AP **310** via wireless links **381**, **383**, **385**, and **387**, respectively. FIG. **3** depicts a wireless link **382** between the wireless client device **370** and the second AP **320** that will result after completing the re-association of the wireless client device **370** from the first AP **310** to the second AP **320**.

[0036] The wireless network **300** may be served by a backhaul LAN **330**. The LAN **330** may be interfaced to a WAN **360** via a gateway **350**. The APs **310**, **320** may be communicatively coupled to the LAN **330** via backhaul links **340** and **342**, respectively. The AP coordination modules **311**, **313** may coordinate with each other to re-associate the wireless client device **370** from the first AP **310** to the second AP **320**. It should be noted that the AP coordination modules **311**, **313** may be implemented as software, hardware, or a combination of software and hardware. For example, the AP coordination modules **311**, **313** may be implemented as a protocol layer of a protocol stack.

[0037] In some implementations, the first AP coordination module **311** may coordinate with the second AP coordination module **313** to determine that the wireless client device **370** should re-associate from the first AP **310** to the second AP **320**. For example, the first AP coordination module **311** may determine that the wireless client device **370** may achieve greater throughput or require less wireless medium utilization on a wireless link (i.e., the wireless link **382**) with the second AP **320**. The first AP coordination module **311** may also determine that an association of the wireless client device **370** with the second AP **320** may result in better load balancing amongst the APs **310**, **320** of the wireless network **300**. For example, the first AP coordination module **311** may receive information about the number of wireless client devices associated with the second AP **320**. The first AP coordination module **311** may determine greater contention by the wireless client devices **370**, **371**, **373**, **375** at the first AP **310** as compared to the lesser contention of fewer devices at the second AP **320**. The first AP coordination module **311** may then determine that the association of the wireless client device **370** with the second AP **320** would result in better load balancing amongst the APs **310**, **320**.

[0038] In one implementation, the first AP coordination module **311** may estimate the throughput and medium time utilized by the wireless client device **370** if the wireless client device **370** was associated with the second AP **320**. The first AP coordination module **311** may then determine whether an association of the wireless client device **370** with the second AP **320** would provide greater throughput or result in less medium time utilized on the wireless link **382**. For example, the first AP coordination module **311** may receive information about channel condition (e.g., channel noise, net throughput at the wireless client device **370**, etc.) between the first AP **310** and the wireless client device **370** from the wireless client device **370**. The first AP coordination module **311** may also receive information about alternative APs (e.g., the second AP **320**) detected by the wireless client device **370**, and a received signal strength of beacon frames from the second AP **320**. The first AP coordination module **311** may receive information from the wireless client device **370** using beacon reports from the wireless client device **370**, an application running on the wireless client device **370**, etc.

[0039] The first AP coordination module **311** may coordinate with AP coordination modules of one or more APs (e.g., the second AP coordination module **313** of the second AP **320**) to determine characteristics of backhaul links of the respective APs. For example, the first AP coordination module **311** may receive information about the available network bandwidth on the backhaul link **342** from the second AP coordination module **313**. The first AP coordination module **311** may also receive information about the number of wireless client devices associated with the second AP **320**, the throughput to each of the wireless client devices and whether the second AP **320** can associate with the wireless client device **370**.

[0040] Based on the information received from the wireless client device **370** and information received from the second AP coordination module **313**, the first AP coordination module **311** may determine to cause the wireless client device **370** to re-associate from the first AP **310** to the second AP **320**. For example, the first AP coordination module **311** may calculate an expected throughput gain that might result from the wireless client device **370** being associated with the second AP **320**. In some implementations, when the throughput gain is not significant (e.g., not above a predetermined threshold), the first AP coordination module **311** may determine not to cause the re-association. The first AP coordination module **311** may also determine whether the association of the wireless client device **370** with the second AP **320** would result in lower utilization of network resources (e.g., shorter data paths, less number of hops, etc.) in the wireless network **300**. On determining that the association of the wireless client device **370** with the second AP **320** would result in lower utilization of the network resources, the first AP coordination module **311** may determine to re-associate the wireless client device **370** from the first AP **310** to the second AP **320**.

[0041] In another implementation, the first AP coordination module **311** may detect unbalanced loads amongst the APs **310**, **320** in the wireless network **300**. The first AP coordination module **311** may detect the unbalanced loads when the channel utilization of the wireless communication medium reaches a level above a predefined threshold. For example, when the wireless client devices **370**, **371**, **373**, and **375** are associated with the first AP **310**, the channel utilization of the wireless communication medium by the first AP **310** may become greater than the predefined threshold. The first AP coordination module **311** may receive information about the alternative APs detected by each of the wireless client devices **370**, **371**, **373**, and **375**. For example, the first AP coordination module **311** may receive information about the alternative APs detected by the wireless client device **370**, and orthogonal channels utilized by the alternative APs for communication over the wireless medium. The first AP coordination module **311** can then determine an AP (e.g., the second AP **320**) that utilizes a different wireless channel than the wire-

less channel utilized by the first AP **310**. For example, the different wireless channels may be orthogonal.

[0042] The first AP coordination module **311** may receive information from the wireless client device **370** using beacon reports from the wireless client device **370**, an application running on the wireless client device **370**, etc. The first AP coordination module **311** may coordinate with the second AP coordination module **313** of the second AP **320** to determine characteristics of the backhaul link **342**. For example, the first AP coordination module **311** may receive information about the available network bandwidth on the backhaul link **342** from the second AP coordination module **313**. The first AP coordination module **311** may also receive information about the number of wireless client devices associated with the second AP **320**, the throughput to each of the wireless client devices and whether the second AP **320** can associate with the wireless client device **370**.

[0043] Based on the information received from the wireless client device **370** and/or information received from the second AP coordination module **313**, the first AP coordination module **311** may determine to cause a re-association of the wireless client device **370** from the first AP **310** to the second AP **320**. For example, the first AP coordination module **311** may determine that on association of the wireless client device **370** with the second AP **320**, the contention at the first AP **310** would decrease while contention at the second AP **320** remains below a predefined threshold. In one example, the first AP coordination module **311** may calculate that the first AP **310** is contended by three wireless client devices (i.e., **371**, **373**, and **375**) after the re-association of the wireless client device **370** to the second AP **320**. The first AP coordination module **311** may also calculate a throughput gain for the wireless client devices **371**, **373**, and **375**, on association of the wireless client device **370** with the second AP **320**. If the throughput gain is above a predefined threshold, the first AP coordination module **311** may determine to re-associate the wireless client device **370** from the first AP **310** to the second AP **320**.

[0044] FIG. **4** depicts an example system diagram to re-associate a wireless client device from a first AP to a second AP of a hybrid network based on backhaul conditions. FIG. **4** includes a hybrid network **400** having a first hybrid network device **410**, a second hybrid network device **420**, and a wireless client device **470**. The first hybrid network device **410** may include an abstraction layer **418** associated with multiple types of network interfaces including a WLAN interface via a central AP **412**, a powerline interface **416**, and an Ethernet interface **414**. It should be understood that while interface **416** is depicted as a powerline communications interface as an example, other technologies could be used. The present disclosure is not limited to a particular backhaul technology. Examples of backhaul technologies might include, without limitation, a powerline communications network (as shown in FIG. **4**), a multimedia over coax (MoCA, not shown), another wireless link (not shown), or any other technology to communicatively couple the first hybrid network device **410** to a gateway **450**.

[0045] In the example depicted in FIG. **4**, the powerline interface **416** may communicatively couple the first hybrid network device **410** via a powerline network **451** to the gateway **450**. The powerline interface **416** and the Ethernet interface **414** may provide separate backhaul links to the gateway **450**. In the example of FIG. **4**, the central AP **412** may provide centralized coordination for one or more other APs in the hybrid network.

[0046] The second hybrid network device **420** may include an abstraction layer **425** associated with multiple types of network interfaces including a WLAN interface via an AP **422**, and an Ethernet interface **426** (as a non-limiting example). The Ethernet interface **426** may communicatively couple the second hybrid network device **420** to a LAN **452**. The central AP **412** and the AP **422** can provide wireless connectivity to the wireless client device **470** in the hybrid network **400**. The central AP **412** and the AP **422** include AP coordination modules **413** and **423** respectively which may coordinate to re-associate the wireless client device **470** from the central AP **412** to the AP **422**. The wireless client device **470** may initially be associated with the central AP **412** via a wireless link **471**. FIG. **4** also depicts a subsequent wireless link **472** between the wireless client device **470** and the AP **422** that may result after the re-association of the wireless client device **470** from the central AP **412** to the AP **422**.

[0047] In some implementations, the hybrid network devices **410**, **420** may be communicatively coupled to the gateway **450** via multiple backhaul links. For example, the first hybrid network device **410** may be communicatively coupled to the gateway **450** via a backhaul link (e.g., powerline network **451**) using the powerline interface **416**. The first hybrid network device **410** may also be communicatively coupled to the gateway **450** using the Ethernet interface **414** via a LAN (not shown). Similarly, the second hybrid network device **420** is communicatively coupled to the gateway **450** via a LAN **452** using the Ethernet interface **426**. Based on the channel characteristics (e.g., noise, contention on the channel), different backhaul links may offer different data rates to the hybrid network devices **410** and **420**. For example, powerline communication medium is susceptible to noise from neighboring electrical devices. The backhaul link using the powerline interface **416** may offer lower data rates to the first hybrid network device **410** as compared to the backhaul link using the Ethernet interface **426**. The AP coordination module **413** may compare available data rates on the backhaul links of the hybrid network devices **410** and **420** to determine whether to re-associate the wireless client device **470** from the central AP **412** to the AP **422**.

[0048] For example, the AP coordination module **413** may determine that the central AP **412** using the backhaul link via the powerline interface **416** offers a first throughput (e.g., 6 Mbps) to the wireless client device **470**, while the AP **422** offers a second throughput (e.g., 54 Mbps) to the wireless client device **470** using the backhaul link via the Ethernet interface **426**. The AP coordination module **413** can determine to re-associate the wireless client device **470** from the central AP **412** to the AP **422** so that the wireless client device **470** may benefit from the second throughput that is higher than the first throughput.

[0049] In another example, the central AP **412** and the AP **422** may offer roughly the same or similar throughput but may have different network paths or network latency. For example, the AP coordination module **413** may determine to re-associate the wireless client device **470** from the central AP **412** to the AP **422** based on reducing the number of hops in path from each of the APs **412**, **422** to a destination (e.g., WAN **460**). In another example, the AP coordination module **413** may determine that the powerline interface **416** is more susceptible to noise due to electrical devices neighboring the

first hybrid network device **410** which may result in greater bit error rates to the wireless client device when the wireless client device **470** uses the central AP **412**. Based on types of backhaul networks or conditions, the AP coordination module **413** may determine to re-associate the wireless client device **470** from the central AP **412** to the AP **422**.

[0050] FIG. **4** depicts the first hybrid network device **410** including the central AP **412**. It is noted that the central AP **412** may coordinate operations for re-association of wireless client devices between one or more APs in the hybrid network **400**. For example, the AP coordination module **413** in the central AP **412** may maintain information about the alternate APs detected by the wireless client device **470**. The AP coordination module **413** may send the information about alternate APs detected by the wireless client device **470** to AP coordination modules of one or more APs requesting the information. It is further noted that the central AP **412** may store the information about re-association activity of the wireless client devices in the hybrid network **400**. For example, the central AP **412** may store the operations performed by the central AP **412** (e.g., a temporary decrease in transmit power of beacon frames by the central AP **412**, etc.) and the AP **422** (e.g., a temporary increase in transmit power of beacon frames by the AP **422**) during the re-association of the wireless client device **470** from the central AP **412** to the AP **422**. The central AP **412** may send the information about re-association activity of a wireless client device when requested by one or more APs in the hybrid network **400**.

[0051] FIG. **5** depicts an example conceptual diagram of an AP coordination message **500** that may be sent from a first AP to a second AP of a wireless network. FIG. **5** includes an example data frame **520**. The data frame **520** may include a preamble **522**, a frame header **524**, a frame body **510**, and a frame check sequence (FCS) **526**. The preamble **522** may include one or more bits to establish synchronization at the second AP (e.g., the second AP **320** as described above with reference to FIG. **3**). The frame header **524** may include source and destination network addresses (e.g., the network address of the APs **310**, **320**, respectively), the length of data frame, or other frame control information. The frame body **510** may be organized with a message format and may include a variety of fields or information elements **532**, **536**, and **538**.

[0052] Various fields or information elements may include coordination information to coordinate the re-association from the first AP to the second AP. Several examples of coordination information elements **560** are illustrated in FIG. **5**. For example, the coordination information elements may include synchronization information **562**, information regarding wireless client device **564**, link characteristic information **566**, or AP performance information **568**. In one implementation, the synchronization information **562** may include a time period within which the wireless client device is scheduled to disassociate from the first AP or a time period within which the wireless client device is expected to associate with the second AP. In one implementation, the synchronization information **562** may indicate a time period during which the first AP will perform re-association activities (such as temporarily decreasing transmit power of beacon frames transmitted by the first AP).

[0053] The information regarding wireless client device **564** may include a device identifier (e.g., network address, media access control (MAC) address, etc.) of the wireless client device. The link characteristic information **566** may include information about the existing wireless link between the wireless client device and the first AP, throughput offered by the first AP to the wireless client device, or other link characteristic information. The AP performance information **568** may include one or more performance parameters of the first AP. For example, the performance parameters may include a number of wireless client devices that can be simultaneously supported by the first AP, a number of wireless client devices currently associated with the first AP, the channels utilized by the first AP for communication over the wireless medium, or other parameters.

[0054] Although, not depicted in FIG. **5**, the information elements **536** may also include one or more instructions from the first AP to the second AP to coordinate the re-association of the wireless client device. For example, the instructions may include an instruction to temporarily (e.g., for a predefined time interval) increase the transmit power of beacon frames transmitted by the second AP. In some implementations, the instructions may also include an instruction to accept the association request from the wireless client device, etc.

[0055] FIG. **6** depicts an example conceptual diagram of a re-association of a first wireless client device **670** from a first AP **610** to a second AP **620** based on detecting network traffic flow between the first wireless client device **670** and a second wireless client device **671** associated with the second AP **620**. FIG. **6** includes a wireless network **600**, similar to the wireless network **100** (as described above with reference to FIG. **1**). The wireless network **600** may be served by a backhaul LAN **630**. The LAN **630** may be interfaced to a WAN **660** via a gateway **650**. The first AP **610** may have a first AP coordination module **611** and the second AP **620** may have a second AP coordination module **613**. The APs **610**, **620** may be similar to the APs described in previous Figures. Similarly, the wireless client devices **670**, **671** may be similar to the wireless client devices described in previous Figures.

[0056] Initially, the first wireless client device **670** is associated with the first AP **610** via a first wireless link **681** and the second wireless client device **671** is associated with the second AP **620** via a second wireless link **683**. Upon completion of the re-association, the first wireless client device **670** and the second AP **620** may establish a new wireless link **682** to replace the first wireless link **681**.

[0057] In one implementation, based, at least in part, on network traffic flow between the first wireless client device **670** and the second wireless client device **671**, the first AP **610** may determine to cause the wireless client device **670** to re-associate from the first AP **610** to the second AP **620**. For example, the first AP coordination module **611** may detect the network traffic flow between the first wireless client device **670** and the second wireless client device **671**. In some implementations, the first AP coordination module **611** may detect the network traffic flow between the first wireless client device **670** and the second wireless client device **671** based on detecting network traffic flow between the first AP **610** and the second AP **620** over the backhaul LAN **630**.

[0058] In some embodiments, the first AP coordination module **611** may determine to cause the re-association for the first wireless client device **670** so that both the first and second wireless client devices **670**, **671** can communicate with each other without the use of backhaul LAN **630** resources. For example, the second AP **620** may bridge traffic from the new wireless link **682** to the second wireless link **683**. Alternatively, the first AP coordination module **611** may determine whether the first wireless client device **670** and the second

wireless client device **671** can support direct peer-to-peer communication (e.g., via a tunneled direct link setup (TDLS)) if both wireless client devices **670**, **671** were associated with the same AP (e.g., second AP **620**).

[0059] The first AP coordination module **611** may also determine whether the first wireless client device **670** can be associated with the second AP **620** (e.g., the received signal strength of beacon frames from the second AP **620** is above a predefined threshold). On determining that the first wireless client device **670** and the second wireless client device **671** can support peer-to-peer communication, the first AP coordination module **611** may determine if a greater throughput can be achieved via a peer-to-peer link between the first wireless client device **670** and the second wireless client device **671** as compared to the throughput via the first AP **610**. In some implementations, the first AP coordination module **611** may also determine that the peer-to-peer link between the first wireless client device **670** and the second wireless client device **671** would result in lower utilization of network resources. For example, once the peer-to-peer link is set up, the network traffic between the first wireless client device **670** and the second wireless client device **671** may not have to traverse through the first AP **610** via the LAN **630** to the second AP **620**.

[0060] If the first AP coordination module **611** determines that causing the first wireless client device **670** to re-associate from the first AP **610** to the second AP **620**, the first AP coordination module **611** may coordinate with the second AP coordination module **613** to cause the re-association of the first wireless client device **670** from the first AP **610** to the second AP **620**.

[0061] FIG. **7** depicts an example sequence diagram **700** of message exchanges between a wireless client device **770**, a first AP **710**, and a second AP **720** to re-associate the wireless client device **770** from the first AP **710** to the second AP **720** in a wireless network. In one implementation, the wireless client device **770** is initially associated with the first AP **710**. The first AP **710** may send a message (shown as arrow **712**) to request a throughput capability of the second AP **720**. The second AP **720** may send a response (shown as arrow **714**) to the first AP **710** including the throughput capability which the second AP **720** may be able to provide to the wireless client device **770**. In some implementations, the first AP **710** may request other performance characteristics (not shown, e.g., latency, contention at the second AP **720**, etc.) from the second AP **720**.

[0062] At **716**, based at least in part on the response **714** from the second AP **720**, the first AP **710** may determine whether to re-associate the wireless client device **770** to the second AP **720**. At **717**, the first AP **710** may send an AP coordination message (as described previously, such as FIG. **5**) to the second AP **720**. For example, the AP coordination message may indicate timing of re-association activities, or an indication of which re-association activities the first AP **710** will perform. At **718**, the first AP **710** may perform the re-association activities. The re-association activities may include, for example, reducing the transmit power of beacon frames transmitted from the first AP **710** for a predefined time interval, as well as forcing a disassociation of the wireless client device **770** from the first AP **710**. Concurrently, the second AP **720** may perform one or more operations at **721** to coordinate the re-association of the wireless client device **770**. For example, the second AP **720** may increase the transmit power of beacon frames transmitted from the second AP **720** for the predefined time interval indicated in the AP coordination message. At **771**, the wireless client device **770** may detect that the signal strength of the beacon frames transmitted from the first AP **710** is lower than the signal strength of the beacon frames transmitted from the second AP **720**. At **772**, the wireless client device **770** may send an association request to the second AP **720**.

[0063] FIG. **8** illustrates a flow diagram **800** of example operations to re-associate a first wireless client device from a first AP to a second AP based on detecting network traffic between the first wireless client device and a second wireless client device associated with the second AP.

[0064] At block **810**, a network traffic flow between a first wireless client device associated with a first AP and a second wireless client device associated with a second AP is detected. In one implementation, an AP coordination module detects the network traffic flow between the first wireless client device and the second wireless client device. For example, the AP coordination module may detect the network flow between the first wireless client device and the second wireless client device based on detecting a flow of traffic on the backhaul LAN between the first AP and the second AP, or based on source and destination network addresses. The AP coordination module may also collect information about which wireless client devices are associated with various APs so that when peer traffic is detected, the AP coordination module can consider a re-association of one or more of the peer devices.

[0065] At block **820**, it is determined that an association of the first wireless client device with the second AP would allow more efficient peer-to-peer communication between the first wireless client device and the second wireless client device. In one implementation, the AP coordination module determines that the association of the first wireless client device with the second AP would allow peer-to-peer communication between the first wireless client device and the second wireless client device that is already associated with the second AP.

[0066] At block **830**, an AP coordination message is communicated from the first AP to the second AP. The AP coordination message can identify the first wireless client device and include coordination information to coordinate a re-association of the first wireless client device from the first AP to the second AP. The AP coordination information in the AP coordination message may include a device identifier of the first wireless client device that is to be re-associated to the second AP. AP coordination information may also describe timing information regarding a selected re-association technique being used to cause the first wireless client device to re-associate to the second AP.

[0067] At block **840**, the first AP coordinates with the second AP to cause the re-association of the first wireless client device in accordance with the coordination information as described previously.

[0068] FIG. **9** illustrates a flow diagram **900** of example operations to re-associate a first wireless client device from a first AP to a second AP by utilizing one of a plurality of re-association techniques.

[0069] At block **902**, a first AP of a wireless network determines to cause a wireless client device to re-associate to a second AP of the wireless network.

[0070] At block **904**, a re-association technique is selected. As described previously, there may be several re-association techniques or activities that may result in re-associating the

wireless client device from the first AP to the second AP. However, not all re-association techniques are supported for various wireless client devices. The APs may attempt different re-association techniques until identifying a re-association technique that successfully results in the re-association. The first AP may select a re-association technique to re-associate the wireless client device based on previous attempts of a particular re-association technique that caused a successful re-association of the wireless client device.

[0071] At block **906**, an AP coordination message is communicated from the first AP to the second AP. The AP coordination message may identify the wireless client device and include coordination information to coordinate the re-association of the wireless client device from the first AP to the second AP. The AP coordination information in the AP coordination message may include a device identifier of the wireless client device. The AP coordination information may also identify the selected re-association technique and timing associated with performing re-association activities for the selected re-association technique.

[0072] At decision **910**, the flow diagram branches to a selected one of plurality of possible re-association activities described in relation to blocks **912**, **914**, and **916**. Blocks **912**, **914**, and **916** each represent different re-association techniques from among a plurality of possible re-association techniques. It should be noted that the re-association techniques described herein are examples and other re-association techniques may be included in the plurality of re-association techniques from which the first AP selects.

[0073] At alternative block **912**, power of beacon frames transmitted by the first AP is adjusted in coordination with changes to power of beacon frames transmitted by the second AP. In one implementation, the first AP and the second AP adjust the transmit power of beacon frames transmitted by the first AP and the second AP, respectively. For example, the first AP may reduce the transmit power of beacon frames transmitted from the first AP for a predefined time interval. The second AP may increase the power of the beacon frames transmitted from the second AP for a predefined interval. The wireless client device may be forced to disassociate from the first AP responsive to a disassociation message from the first AP. Alternatively, the wireless client device may choose to disassociate based on the change in power level of the beacon frames transmitted by the first AP. The wireless client device may discover the second AP and determined that the received signal strength of the beacon frames received from the second AP is stronger than the received signal strength of the beacon frames received from the first AP. As a result of the relative signal strengths, the wireless client device may choose to associate with the second AP.

[0074] At alternative block **914**, a configuration parameter is sent to the first wireless client device identifying at least the second AP, the configuration parameter representing a suggestion to the wireless client device to reselect and associated with the second AP. For example, the configuration parameter may include a device identifier (e.g., MAC address, service set identifier (SSID), or other identifier) of the second AP. Alternatively, the configuration parameter may include an explicit instruction for the wireless client device to associate with the second AP if the wireless client device is capable of interpreting the explicit instruction. In some implementations, the first AP may send device identifiers of a plurality of APs in the configuration parameter and indicate to the wireless client device to associate with an AP from the plurality of APs based on RSSI of beacon frames from the plurality of APs.

[0075] At alternative block **916**, a disassociation instruction is sent to the wireless client device to force the wireless client device to perform a new network discovery and selection. In one implementation, the first AP sends the disassociation instruction to the wireless client device. For example, the disassociation instruction may instruct the wireless client device to disassociate from the first AP within a predefined time interval. The disassociation instruction may also instruct the wireless client device to perform discovery of a new AP and not to associate with the first AP even if the first AP is discovered. In some implementations, the first AP may block further traffic from the wireless client device to prevent the wireless client device from associating with the first AP again.

[0076] From blocks **912**, **914**, **916**, the flow diagram continues to decision **917**. At **917**, if the re-association technique **912**, **914**, or **916** was unsuccessful in causing the desired re-association, then the flow may return to block **904** to select a different re-association technique. If the re-association technique **912**, **914**, **916** was successful in causing the desired re-association, then the flow may continue to block **918**.

[0077] At block **918**, a record of re-association activity performed for the wireless client device is maintained. The record identifies the re-association activity or activities which successfully caused the re-association of the wireless client device from the first AP to the second AP. In one implementation, the first AP may receive a confirmation from the second AP that the wireless client device has successfully associated with the second AP. On receiving the confirmation, the first AP may store the record of re-association activity for the wireless client device. For example, the record of re-association activity may include a device identifier (e.g., MAC address) of the wireless client device and one of the re-association techniques (such as those described at blocks **912**, **914**, and **916**) that was successfully used to re-associate the wireless client device from the first AP to the second AP. In some implementations, the record of re-association activity may also include device identifiers of the first and second APs (i.e., the first AP and the second AP). The record may also store the average latency or delay associated with the successful re-association technique.

[0078] If the wireless client device should later become re-associated with the first AP and the first AP determines to cause another re-association, the first AP may utilize the record of previous re-associations (see block **918**) in the subsequent selection of re-association technique. Over several attempts and re-associations, the access points may become aware of the capabilities of particular wireless client devices. The capabilities and associated delay of different re-association techniques may be considered when selecting a re-association technique for a particular wireless client device.

[0079] It is noted that the operations described in flow diagrams of FIGS. **2**, **8**, and **9** are exemplary in nature. It is further noted that the flow diagrams of FIGS. **2**, **8**, and **9** do not depict all embodiments to re-associate a wireless client device from a first AP to a second AP. For example, the operations at block **840** may include one of the re-association techniques described at block **912**, **914**, **916** of FIG. **9**.

[0080] It should be understood that FIGS. **1-10** and the operations described herein are examples meant to aid in

understanding embodiments and should not be used to limit embodiments or limit scope of the claims. Embodiments may perform additional operations, fewer operations, operations in parallel or in a different order, and some operations differently.

[0081] As will be appreciated by one skilled in the art, aspects of the present disclosure may be embodied as a system, method, or computer program product. Accordingly, aspects of the present disclosure may take the form of an entirely hardware embodiment, a software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a "circuit," "module" or "system." Furthermore, aspects of the present disclosure may take the form of a computer program product embodied in one or more computer readable medium(s) having computer readable program code embodied thereon.

[0082] Any combination of one or more non-transitory computer readable medium(s) may be utilized. Non-transitory computer-readable media comprise all computer-readable media, with the sole exception being a transitory, propagating signal. The non-transitory computer readable medium may be a computer readable storage medium. A computer readable storage medium may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples (a non-exhaustive list) of the computer readable storage medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer readable storage medium may be any tangible medium that can contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device.

[0083] Computer program code embodied on a computer readable medium for carrying out operations for aspects of the present disclosure may be written in any combination of one or more programming languages, including an object oriented programming language such as Java, Smalltalk, C++ or the like and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The program code may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider).

[0084] Aspects of the present disclosure are described with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems) and computer program products according to embodiments of the present disclosure. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0085] These computer program instructions may also be stored in a computer readable medium that can direct a computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions stored in the computer readable medium produce an article of manufacture including instructions which implement the function/act specified in the flowchart and/or block diagram block or blocks. The computer program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other devices to cause a series of operational steps to be performed on the computer, other programmable apparatus or other devices to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0086] FIG. **10** is an example block diagram of one embodiment of an electronic device **1000** capable of implementing various embodiments in accordance with this disclosure. The electronic device **1000** includes a processor unit **1002** (possibly including multiple processors, multiple cores, multiple nodes, and/or implementing multi-threading, etc.). The electronic device **1000** includes a memory unit **1006**. The memory unit **1006** may be system memory (e.g., one or more of cache, SRAM, DRAM, zero capacitor RAM, Twin Transistor RAM, eDRAM, EDO RAM, DDR RAM, EEPROM, NRAM, RRAM, SONOS, PRAM, etc.) or any one or more of the above already described possible realizations of machine-readable media. The electronic device **1000** also includes a bus **1010** (e.g., PCI, ISA, PCI-Express, HyperTransport®, InfiniBand®, NuBus, AHB, AXI, etc.), and network interfaces **1004** that include at least one of a wireless network interface (e.g., a WLAN interface, a Bluetooth® interface, a WiMAX interface, a ZigBee® interface, a Wireless USB interface, etc.) and a wired network interface (e.g., a powerline communication interface, an Ethernet interface, etc.).

[0087] The electronic device **1000** may include an AP coordination module **1016**. The AP coordination module **1016** may be capable of performing various methods, techniques, operations, etc. described herein. For example, the AP coordination module **1016** may be suitable for coordinating with one or more APs in a wireless network to cause a wireless client device to re-associate to another AP in accordance with embodiments of this disclosure. Any one of these functionalities may be partially (or entirely) implemented in hardware and/or on the processor unit **1002**. For example, the functionality may be implemented with an application specific integrated circuit, in logic implemented in the processor unit **1002**, in a co-processor on a peripheral device or card, etc. Further, realizations may include fewer or additional components not illustrated in FIG. **10** (e.g., video cards, audio cards, additional network interfaces, peripheral devices, etc.). The processor unit **1002**, the memory unit **1006**, and the network interfaces **1004** are coupled to the bus **1010**. Although illus-

trated as being coupled to the bus **1010**, the memory unit **1006** may be coupled to the processor unit **1002**.

[0088] While the embodiments are described with reference to various implementations and exploitations, it will be understood that these embodiments are illustrative and that the scope of the present disclosure is not limited to them. In general, techniques for implementing a re-association of a wireless client device from a first AP to a second AP in a wireless network as described herein may be implemented with facilities consistent with any hardware system or hardware systems. Many variations, modifications, additions, and improvements are possible.

[0089] Plural instances may be provided for components, operations or structures described herein as a single instance. Finally, boundaries between various components, operations and data stores are somewhat arbitrary, and particular operations are illustrated in the context of specific illustrative configurations. Other allocations of functionality are envisioned and may fall within the scope of the present disclosure. In general, structures and functionality presented as separate components in the exemplary configurations may be implemented as a combined structure or component. Similarly, structures and functionality presented as a single component may be implemented as separate components. These and other variations, modifications, additions, and improvements may fall within the scope of the present disclosure.

What is claimed is:

1. A method comprising:

determining, at a first access point (AP) of a wireless network, to cause a wireless client device communicatively coupled with the first AP to re-associate from the first AP to a second AP of the wireless network;

communicating an AP coordination message from the first AP to the second AP, the AP coordination message identifying the wireless client device and including re-association coordination information; and

coordinating the first AP with the second AP to cause the re-association of the wireless client device to the second AP in accordance with the re-association coordination information.

2. The method of claim **1**, wherein coordinating the first AP with the second AP to cause the re-association of the wireless client device includes attempting at least one re-association activity to cause the wireless client device to re-associate to the second AP, the re-association activity selected from a group comprising at least one of:

decreasing transmit power of beacon frames transmitted by the first AP;

sending a configuration parameter to the wireless client device identifying at least the second AP to cause the wireless client device to re-associate to the second AP;

sending a disassociation instruction to the wireless client device to force the wireless client device to perform a new network discovery and selection; and

blocking, at the first AP, at least one incoming packet from the wireless client device to force the wireless client device to perform a new network discovery and selection.

3. The method of claim **2**, wherein decreasing transmit power of beacon frames transmitted by the first AP includes coordinating said decreasing transmit power of beacon frames transmitted by the first AP in coordination with an increase of transmit power of beacon frames transmitted by the second AP.

4. The method of claim **2**, wherein the re-association coordination information includes timing information to synchronize the re-association activity.

5. The method of claim **2**, further comprising:

maintaining a record of previous re-association activity performed for the wireless client device, wherein the record identifies the wireless client device and indicates the previous re-association activity that successfully caused the re-association of the wireless client device from the first AP to the second AP.

6. The method of claim **5**, wherein the record further includes latency associated with an amount of time between a beginning of the previous re-association activity and a completion of the previous re-association activity.

7. The method of claim **5**, further comprising:

selecting which re-association activity to perform based, at least in part, on the record of the previous re-association activity.

8. The method of claim **1**, wherein coordinating the first AP with the second AP to cause the re-association of the wireless client device includes temporarily reducing transmit power of first beacon frames at the first AP.

9. The method of claim **8**, wherein the AP coordination message includes an indicator to cause the second AP to increase transmit power of second beacon frames transmitted by the second AP.

10. The method of claim **1**, wherein coordinating the first AP with the second AP to cause the re-association of the wireless client device includes sending a disassociation instruction to the wireless client device.

11. The method of claim **10**, further comprising:

blocking, at the first AP, at least one incoming packet from the wireless client device.

12. The method of claim **1**, wherein coordinating the first AP with the second AP to cause the re-association of the wireless client device includes:

sending a configuration parameter to the wireless client device to cause the wireless client device to associate with the second AP, the configuration parameter identifying at least the second AP.

13. The method of claim **12**, wherein the configuration parameter includes a list of candidate APs that includes at least the second AP.

14. The method of claim **1**, wherein determining to cause the wireless client device communicatively coupled with the first AP to re-associate from the first AP to the second AP includes:

determining a first performance characteristic related to wireless association between the wireless client device and the first AP;

estimating a second performance characteristic related to a potential wireless association between the wireless client device and the second AP; and

determining that the second performance characteristic is greater than the first performance characteristic.

15. The method of claim **14**, wherein communicating the AP coordination message is responsive to determining that the second performance characteristic is greater than the first performance characteristic.

16. The method of claim **1**, wherein determining to cause the wireless client device communicatively coupled with the first AP to re-associate from the first AP to the second AP includes:

determining that an association of the wireless client device with the second AP would provide greater application throughput to the wireless client device.

17. The method of claim **1**, wherein determining to cause the wireless client device communicatively coupled with the first AP to re-associate to the second AP includes:

determining that an association of the wireless client device with the second AP would improve load balancing between the first AP and the second AP.

18. The method of claim **1**, wherein determining to cause the wireless client device communicatively coupled with the first AP to re-associate from the first AP to the second AP includes:

determining that an association of the wireless client device with the second AP would allow peer-to-peer communication between the wireless client device and other wireless client devices associated with the second AP.

19. The method of claim **18**, wherein determining that the association of the wireless client device with the second AP would allow peer-to-peer communication between the wireless client device and other wireless client devices associated with the second AP includes detecting a network traffic flow between the wireless client device and at least one wireless client device associated with the second AP.

20. The method of claim **1**, wherein determining to cause the wireless client device communicatively coupled with the first AP to re-associate from the first AP to the second AP includes:

determining, at the first AP, to disassociate the wireless client device from the first AP based on information received at a first AP coordination module of the first AP.

21. The method of claim **1**, further comprising:

receiving, at the first AP, a confirmation that the wireless client device has become associated with the second AP.

22. A first access point (AP) of a wireless network, the first AP comprising:

a network interface operable to couple with the wireless network;

an AP coordination module operable to:

determine, at the first access point (AP), to cause a wireless client device communicatively coupled via the network interface with the first AP to re-associate from the first AP to a second AP of the wireless network;

communicate an AP coordination message from the first AP to the second AP, the AP coordination message identifying the wireless client device and including re-association coordination information; and

coordinate the first AP with the second AP to cause the re-association of the wireless client device to the second AP in accordance with the re-association coordination information.

23. The first AP of claim **22**, wherein the AP coordination module operable to coordinate the first AP with the second AP to cause the re-association of the wireless client device comprises the AP coordination module operable to:

attempt at least one re-association activity to cause the wireless client device to re-associate with the second AP, the re-association activity selected from a group comprising:

decreasing transmit power of beacon frames transmitted by the first AP;

sending a configuration parameter to the wireless client device identifying at least the second AP to cause the wireless client device to re-associate to the second AP;

sending a disassociation instruction to the wireless client device to force the wireless client device to perform a new network discovery and selection; and

blocking, at the first AP, at least one incoming packet from the wireless client device to force the wireless client device to perform a new network discovery and selection.

24. The first AP of claim **23**, wherein decreasing transmit power of beacon frames transmitted by the first AP includes coordinating said decreasing transmit power of beacon frames transmitted by the first AP in coordination with an increase of transmit power of beacon frames transmitted by the second AP.

25. The first AP of claim **23**, wherein the re-association coordination information includes timing information to synchronize the re-association activity.

26. The first AP of claim **23**, wherein the AP coordination module is further operable to:

maintain a record of previous re-association activity performed for the wireless client device, wherein the record identifies the wireless client device and indicates the previous re-association activity that successfully caused the re-association of the wireless client device from the first AP to the second AP.

27. The first AP of claim **26**, wherein the record further includes latency associated with an amount of time between a beginning of the previous re-association activity and a completion of the previous re-association activity.

28. The first AP of claim **26**, wherein the AP coordination module is further operable to:

select which re-association activity to perform based, at least in part, on the record of the previous re-association activity.

29. The first AP of claim **22**, wherein the AP coordination module operable to coordinate the first AP with the second AP to cause the wireless client device to re-associate from the first AP to the second AP comprises the AP coordination module operable to temporarily reduce transmit power of first beacon frames transmitted via the network interface at the first AP.

30. The first AP of claim **29**, wherein the AP coordination message includes an indicator to cause the second AP to increase transmit power of second beacon frames transmitted by the second AP.

31. The first AP of claim **22**, wherein the AP coordination module operable to determine to cause the wireless client device communicatively coupled with the first AP to re-associate from the first AP to the second AP includes the AP coordination module operable to:

determine that an association of the wireless client device with the second AP would provide greater application throughput to the wireless client device.

32. The first AP of claim **22**, wherein the AP coordination module operable to determine to cause the wireless client device communicatively coupled with the first AP to re-associate from the first AP to the second AP includes the AP coordination module operable to:

determine that an association of the wireless client device with the second AP would improve load balancing between the first AP and the second AP.

33. The first AP of claim **22**, wherein the AP coordination module operable to determine to cause the wireless client device communicatively coupled with the first AP to re-associate from the first AP to the second AP includes the AP coordination module operable to:

determine that an association of the wireless client device with the second AP would allow peer-to-peer communication between the wireless client device and other wireless client devices associated with the second AP.

34. The first AP of claim **33**, wherein the AP coordination module operable to determine that the association of the wireless client device with the second AP would allow peer-to-peer communication between the wireless client device and other wireless client devices associated with the second AP comprises the AP coordination module operable to:

detect a network traffic flow between the wireless client device and at least one wireless client device associated with the second AP.

35. A non-transitory computer readable medium storing instructions which, when executed by one or more processors of a device, cause the device to perform operations comprising:

determining, at a first access point (AP) of a wireless network, to cause a wireless client device communicatively coupled with the first AP to re-associate from the first AP to a second AP of the wireless network;

communicating an AP coordination message from the first AP to the second AP, the AP coordination message identifying the wireless client device and including re-association coordination information; and

coordinating the first AP with the second AP to cause the re-association of the wireless client device to the second AP in accordance with the re-association coordination information.

36. The non-transitory computer readable medium of claim **35**, wherein the instructions, when executed by one or more processors of a device, cause the device to perform an operation comprising:

attempting at least one re-association activity to cause the wireless client device to re-associate to the second AP, the re-association activity selected from a group comprising at least one of:

decreasing transmit power of beacon frames transmitted by the first AP;

sending a configuration parameter to the wireless client device identifying at least the second AP to cause the wireless client device to re-associate to the second AP;

sending a disassociation instruction to the wireless client device to force the wireless client device to perform a new network discovery and selection; and

blocking, at the first AP, at least one incoming packet from the wireless client device to force the wireless client device to perform a new network discovery and selection.

37. The non-transitory computer readable medium of claim **36**, wherein decreasing transmit power of beacon frames transmitted by the first AP includes coordinating said decreasing transmit power of beacon frames transmitted by the first AP in coordination with an increase of transmit power of beacon frames transmitted by the second AP.

38. The non-transitory computer readable medium of claim **36**, wherein the re-association coordination information includes timing information to synchronize the re-association activity.

39. The non-transitory computer readable medium of claim **36**, wherein the instructions, when executed by one or more processors of a device, cause the device to perform an operation comprising:

maintaining a record of previous re-association activity performed for the wireless client device, wherein the record identifies the wireless client device and indicates a previous re-association activity that successfully caused the re-association of the wireless client device from the first AP to the second AP.

40. The non-transitory computer readable medium of claim **39**, wherein the record further includes latency associated with an amount of time between a beginning of the previous re-association activity and a completion of the previous re-association activity.

41. The non-transitory computer readable medium of claim **39**, wherein the instructions, when executed by one or more processors of a device, cause the device to perform an operation comprising:

selecting which re-association activity to perform based, at least in part, on the record of the previous re-association activity.

42. The non-transitory computer readable medium of claim **35**, wherein the instructions that cause the device to coordinate the first AP with the second AP to cause the re-association of the wireless client device comprises instructions, when executed by one of more processors of the device, cause the device to temporarily reduce transmit power of first beacon frames transmitted via a network interface at the first AP.

43. The non-transitory computer readable medium of claim **42**, wherein the AP coordination message includes an indicator to cause the second AP to increase transmit power of second beacon frames transmitted by the second AP.

44. The non-transitory computer readable medium of claim **35**, wherein the instructions that cause the device to determine to cause the wireless client device communicatively coupled with the first AP to re-associate from the first AP to the second AP comprises instructions, when executed by one of more processors of the device, cause the device to:

determine that an association of the wireless client device with the second AP would provide greater application throughput to the wireless client device.

45. The non-transitory computer readable medium of claim **35**, wherein the instructions that cause the device to determine to cause the wireless client device communicatively coupled with the first AP to re-associate from the first AP to the second AP comprises instructions, when executed by one of more processors of the device, cause the device to:

determine that an association of the wireless client device with the second AP would improve load balancing between the first AP and the second AP.

46. The non-transitory computer readable medium of claim **35**, wherein the instructions that cause the device to determine to cause the wireless client device communicatively coupled with the first AP to re-associate from the first AP to the second AP comprises instructions, when executed by one of more processors of the device, cause the device to:

determine that an association of the wireless client device with the second AP would allow peer-to-peer commu-

nication between the wireless client device and other wireless client devices associated with the second AP.

47. An apparatus comprising:

means for determining to cause a wireless client device communicatively coupled with a first AP to re-associate from the first AP to a second AP of a wireless network;

means for communicating an AP coordination message from the first AP to the second AP, the AP coordination message identifying the wireless client device and including re-association coordination information; and

means for coordinating the first AP with the second AP to cause the re-association of the wireless client device to the second AP in accordance with the re-association coordination information.

48. The apparatus of claim **47**, wherein the means for coordinating the first AP with the second AP to cause the wireless client device to re-associate from the first AP to the second AP includes means for attempting at least one re-association activity to cause the wireless client device to re-associate to the second AP, the re-association activity selected from a group comprising at least one of:

decreasing transmit power of beacon frames transmitted by the first AP;

sending a configuration parameter to the wireless client device identifying at least the second AP to cause the wireless client device to re-associate from the first AP to the second AP;

sending a disassociation instruction to the wireless client device to force the wireless client device to perform a new network discovery and selection; and

blocking, at the first AP, at least one incoming packet from the wireless client device to force the wireless client device to perform a new network discovery and selection.

* * * * *