[0001] PEER-TO-PEER WIRELESS COMMUNICATION SYSTEM

[0002] FIELD OF INVENTION

[0003] The present invention is related to a wireless communication system including a plurality of wireless stations (STAs) and an access point (AP), (i.e., a centralized controller), and a wireless communication system including a plurality of STAs without a centralized controller, (i.e., an Ad hoc network). More particularly, the present invention is related to a method and system for establishing data transfers between the STAs using a direct link setup (DLS).

[0004] BACKGROUND

[0005] Typically, STAs are not allowed to transmit data packets directly to other STAs in a Basic Service Set (BSS) and, instead, must always rely on the AP for the delivery of the data packets. However, STAs with a quality of service (QoS) facility, (i.e., QSTAs), may transmit data packets directly to another QSTA by establishing a data transfer using a DLS. The IEEE 802.11e standard is associated with the support of QoS features such as service differentiation, block acknowledgement (ACK) and DLS. The STAs that support these IEEE 802.11e features are referred as QSTAs. Similarly, an AP that supports these IEEE 802.11e features is referred to as a QAP. The need for the DLS is motivated by the fact that the intended recipient STA may be in a power save mode, whereby the recipient QSTA may only be activated, (i.e., awakened), by an AP with a QoS facility, (i.e., QAP). The DLS exchanges a rate set and other information between a transmitter in one QSTA and a receiver in another QSTA. DLS messages may be used to attach security information elements (IEs).

[0006] SUMMARY

[0007] The present invention is related to a peer-to-peer communication system using a DLS. A mobile station (STA) establishes a direct communication link with another STA by sending a message requesting a DLS to an access point (AP), (i.e., a centralized controller). The AP may accept or reject the DLS request

based on channel measurements. If the DLS request is accepted, the DLS is established such that the STAs may directly communicate with each other. An established DLS connection may be torn down by the AP sending a message including a DLS teardown request to one of the STAs, or based on channel measurements. The system may be an Ad hoc network comprising a plurality of STAs without an AP where each STA maintains a database of one-hop and two-hop STAs, and establishes a direct link to other STAs after informing neighboring STAs of an intention to establish a direct communication link.

[0008] BRIEF DESCRIPTION OF THE DRAWINGS

[0009] A more detailed understanding of the invention may be had from the following description of a preferred embodiment, given by way of example and to be understood in conjunction with the accompanying drawings wherein:

[0010] Figure 1 is an exemplary block diagram of a wireless communication system including a plurality of QSTAs and a QAP in accordance with the present invention;

[0011] Figure 2 is a block diagram of an Ad hoc network comprising a plurality of STAs for supporting peer-to-peer communication in accordance with the present invention; and

[0012] Figure 3 is a block diagram of a network comprising a plurality of STAs and an AP for supporting peer-to-peer communication in accordance with the present invention.

[0013] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] Hereafter, the terminology "STA" or "QSTA" includes but is not limited to a wireless transmit/receive unit (WTRU), a user equipment, a mobile station, a fixed or mobile subscriber unit, a pager, or any other type of device capable of operating in a wireless environment. When referred to hereafter, the terminology "AP" or "QAP" includes but is not limited to a base station, a Node-B, a site controller, a centralized controller or any other type of interfacing device in a wireless environment.

[0015] The features of the present invention may be incorporated into an integrated circuit (IC) or be configured in a circuit comprising a multitude of interconnecting components.

[0016] The present invention facilitates the establishment of data transfers between QSTAs of a peer-to-peer wireless communication system, such as a wireless local area network (WLAN) or a wireless wide area network (WWAN), using a DLS. The present invention further performs a signaling procedure for establishing the DLS, tearing down the DLS, and performing a data transfer with hybrid coordination function controlled channel access (HCCA) or enhanced distributed channel access (EDCA).

[0017] Additional details regarding DLS, HCCA and EDCA are disclosed in copending U.S. Patent Appln. No. 11/199,446 entitled "Method and System for Controlling Access to a Wireless Communication Medium" by Sudheer A. Grandhi et al., which is incorporated by reference as if fully set forth.

[0018] Figure 1 is an exemplary block diagram of a wireless communication system 100 including a plurality of QSTAs 12a, 12b and a QAP 10. Similar to conventional wireless communication systems, the QSTA 12a intends to exchange data packets directly with the QSTA 12b. The QSTA 12a invokes a DLS by including a DLS request frame in a message 102 sent to the QAP 10 by the QSTA 12a. The message 102 may include a rate set, capability information of the QSTA 12a, the medium access control (MAC) addresses of the QSTAs 12a and 12b, or other necessary information. If the QSTA 12b is associated with the QAP 10 in a basic service set (BSS) that has a policy which allows direct data transfers to take place between QSTAs, the QAP 10 forwards the DLS request frame in a message 104 to the QSTA 12b. If the QSTA 12b accepts the DLS request frame, the QSTA 12b includes a DLS response frame in a message 106 sent to the QAP 10 by the QSTA 12b which contains a rate set. The QAP 10 includes the DLS response frame in a message 108 sent to the QSTA 12a. Thereafter, a direct communication link 110 is established between the QSTA 12a and the QSTA 12b.

[0019] In accordance with the present invention, the QAP 10 may reject the

DLS request received from the QSTA 12a due to inadequate channel quality of signals associated with the QSTAs 12a, 12b, and thus the QAP 10 will not send the message 104 to the QSTA 12b. The DLS request frame included in the message 102 includes an IE for optimal physical layer (PHY) rate and/or other channel quality information between the QSTAs 12a and 12b. This information may be obtained from previous transmissions between the QSTA 12a and the QSTA 12b, or by listening to the transmissions from the QSTA 12b, (received by the QAP 10 or other QSTAs). If the information is not available, the QSTA 12a sends the message 102 with the IE set to 0, (i.e., null).

[0020] If the QSTA 12a needs to perform a search for the QSTA 12b, the QSTA 12a may include a DLS discovery request frame in a message 112 sent to the QAP 10. If the QAP 10 is aware of the QSTA 12b, the QAP 10 includes a DLS discovery response frame with relevant MAC information in a message 114 sent to the QSTA 12a. Otherwise, the QAP 10 includes the DLS discovery response frame and an indication that the QSTA 12b could not be located in the message 114. This procedure is performed before the DLS is established.

[0021] Referring to Figure 1, additional messages may be further exchanged before or after the DLS is established. The QAP 10 may optionally include a DLS measurement request packet in a message 116 sent to the QSTA 12a to request a channel quality measurement. The message 116 may also include information regarding the capability of QSTA 12b to perform a channel quality measurement. The capability information includes, but is not limited to, a number of antennas, and an indication of the type of antenna technology supported such as multiple-input multiple-output (MIMO), antenna diversity or any other smart antenna technology. The QSTA 12a responds to the message 116 by including a measurement response packet in a message 118 sent to the QAP 10. The message 118 may also include the channel quality measurement results between the QSTA 12a and the QSTA 12b. Channel measurements may include received signal strength indication (RSSI) between QSTA12a to QSTA12b, channel quality indicator (CQI) between QSTA 12a and QSTA 12b and interference level at QSTA 12a. RSSI is measured at QSTA 12a from QSTA 12b

by passively listening to packets sent from the QSTA 12b to the QAP 10 or other QSTAs/STAs. CQI measurements may be obtained by actively transmitting packets from QSTA 12a to QSTA 12b even before the DLS is implemented. The messages 116 and 118 may be exchanged before message 108 is sent by the QAP 10 or during an ongoing DLS session.

[0022] In conventional wireless communication systems, the DLS may be torn down by either one of the two QSTAs 12a, 12b. The DLS teardown process cannot be initiated by the QAP 110. The QSTAs 12a, 12b can teardown the DLS due to inactivity or completion of an application. Each QSTA 12a, 12b may include a timer which is reset each time a packet is received, (a data packet or an acknowledgement (ACK) packet), from the other QSTA 12a, 12b. The timer is used to end the DLS due to a link failure or completion of an application. If no packets are received before the timer expires, or an application is completed, the QSTA 12a, 12b initiates a DLS teardown process by including a DLS teardown packet in a message 120a, 120b sent to the QAP 10. After the DLS teardown process is completed, all packets sent by the QSTAs 12a, 12b are processed by the QAP 10.

[0023] Either of the QSTAs 12a, 12b may send the send the DLS teardown packet to the QAP 10. Once the DLS teardown message 120 is sent by one of the QSTAs 12a, 12b, the QAP 10 will forward the DLS teardown message to the other one of the QSTAs 12a, 12b. The DLS teardown process may be implemented in any access method, (e.g., an assigned resource allocation, a management resource allocation, HCCA or EDCF).

[0024] In accordance with the present invention, the QAP 10 may initiate a DLS teardown by sending a DLS response message 108 including a DLS teardown action field to either of the QSTAs 12a or 12b. The action frame includes a timer information field whereby the QSTA 12a or 12b must respond by sending a DLS teardown message to the QAP 10 before the timer expires. This feature is backward compatible with current WLAN standards.

[0025] The QAP 10 may initiate a DLS between two QSTAs 12a and 12b. The QAP 10 sends a DLS initiate message to each of the QSTAs 12a and 12b.

Once the QAP 10 receives a DLS request message from both of the QSTAs 12a and 12b in the response of the DLS initiate message, the QAP 10 may send a DLS response message to both of the QSTAs 12a and 12b. The DLS initiate message is a new message introduced by the present invention to allow the QAP 10 to initiate a DLS between two STAs. Alternatively, the DLS request message and the DLS response message may be modified to initiate a DLS from the QAP 10 instead of creating a new DLS initiate message.

[0026] Data transfer after the DLS is established is explained hereinafter. The QSTAs may use the DLS for performing data transfers using any of the access mechanisms defined in IEEE 802.11e standards, such as an HCCA or an EDCF.

[0027] The present invention provides several action frame formats for DLS management purposes. An action field, immediately after the category field, differentiates the formats. The action field values associated with each frame format are defined in Table 1.

Action Field Value	Meaning
0	DLS request
1	DLS response
2	DLS teardown
3-255	Reserved

Table 1.

Additional action field values are defined in accordance with the present invention. A DLS discovery request frame is for a QSTA to get a MAC address of another QSTA by sending application requirements. A DLS discovery response frame is for a QAP to respond back with the MAC address of the requested QSTA. A conventional DLS teardown frame is modified to add an action field for DLS teardown by the QAP. An information field called a timer is included in the DLS teardown frame. The QAP expects that a QSTA would send the DLS teardown message to the QAP before the timer expires. A conventional DLS request frame is modified to include an additional element to send optimal PHY data rate and certain other channel characteristic between the two QSTAs. A DLS measurement request frame is for measurement request from a QAP to a QSTA. The DLS measurement request frame contains capability information of another QSTA. A DLS measurement response frame is for DLS measurement response from a QSTA to a QAP. The DLS measurement response frame contains measurement information and another QSTA MAC address.

[0028] Figure 2 is a block diagram of an Ad hoc network 200 comprising a plurality of QSTAs 12a, 12b, 12c, 12d, 12e, 12f for supporting peer-to-peer communication in accordance with another embodiment of the present invention. Each of the QSTAs 12a-12f maintains a database (not shown) of all of the QSTAs 12a-12f within one hop and two hops. One hop QSTAs are QSTAs that can hear each other and are referred to hereinafter as "neighbors". Two hop QSTAs are QSTAs that cannot be heard directly, but a neighbor can hear.

[0029] There are two groups of QSTAs that need to be informed when the media will be in use, the QSTAs that can hear the transmission and the QSTAs

that could possibly transmit and interfere with the reception. Therefore, only a transmitting QSTA and a receiving QSTA need to inform their neighbor QSTAs, respectively. The transmitting QSTA needs to tell its neighbors that the medium is in use and the neighbors cannot receive without interference. The receiving QSTA needs to tell its neighbors that the medium is in use and that the neighbors should not transmit. This may require some handshaking to be properly implemented, but it will yield better overall medium efficiency.

[0030] Neighboring QSTAs send signals between each other to report capabilities via capability messages. The capability messages may be transmitted as a part of an initialization process when a QSTA is powered on. The capability messages may be periodic or event-triggered by some activity or inactivity of any QSTA, or can also be a reply to an information request signal initiated by one of the QSTAs.

[0031] A new QSTA may send a broadcast message to neighbors asking for active transmission. The new QSTA may passively scan the channels and then send directed packets. Upon reception of the request, any QSTA in active secession may send the information back to the new QSTA. The QSTAs follow a random back off before responding. Once the new QSTA gets the information, the new QSTA uses this information to optimally allocate resources for starting a new application.

[0032] For example, in the Ad hoc network 200 of Figure 2, the QSTA 12a and the QSTA 12b intend to communicate with each other. Before running an application between QSTA 12a and QSTA 12b, one or both of the QSTA 12a and QSTA 12b inform neighbors by sending messages 202 about the application. The message 202 may be sent as a broadcast and/or propagated to the two hop QSTAs. Alternatively, the message 202 may include a packet directed to specific QSTAs. After informing neighboring QSTAs of the intended communication, the QSTA 12a and the QSTA 12b may communicate by exchanging messages 204 without interference.

[0033] Information that is communicated between the QSTAs 12a, 12b may include, but is not limited to, bandwidth requirement, identification of the

transmitting QSTA and the receiving QSTA, a frequency band, a preferred modulation mode, sub- carriers, a MIMO enabled code, or the like. This information should preferably be communicated during the establishment of DLS. However, it may be communicated during the DLS communication to update certain parameters such as preferred modulation. This information may be resent in response to a request from another QSTA. The QSTAs can ask for this information to update their statistics or to start a new application.

[0034] Some services or applications may have priority over others, whereby they may disrupt other services if required. An example of this service is voice-over-IP (VoIP) for emergency (911) calls. The disruption can be performed by a message exchange between other transmitting QSTAs to stop their service, or by a message exchange to re-negotiate a bandwidth, a sub-carrier, a frequency band, or the like.

[0035] Figure 3 is a block diagram of a network 300 including a plurality of QSTAs 12a - 12f and a QAP 14 in accordance with the present invention. Similar to the Ad hoc network 200 of Figure 2, each of the QSTAs 12a-12f maintains a database of all QSTAs with which each QSTA 12a-12f can directly communicate and with which each QSTA 12a-12f can communicate through the QAP 14. The QAP 14 may provide the database of QSTAs available through the QAP 14.

[0036] Each of the QSTAs 12a-12f is connected to the QAP 14. However, all traffic does not necessarily originate from or pass through the QAP 14. Thus, two QSTAs may communicate with each other directly without sending the traffic through the QAP 14. This process may be controlled by the QAP 14 and a distributed control which is similar to the non-AP case described above with reference to Figure 2.

[0037] In the process controlled by the QAP 14, for example, a QSTA 12a intends to communicate with a QSTA 12b. The QSTA 12a sends a message 302 to the QAP 14 which includes at least one of a destination ID, a required bandwidth, channel information, a direct hop to the destination, or the like. Based on the information provided in message 302, the QAP 14 determines whether to let the two QSTAs 12a, 12b directly communicate, or communicate

through the QAP 14. The QAP 14 may make this determination based on the signal strength between the two QSTAs 12a, 12b, current network load, activity of the QAP 14, capability of the two QSTAs 12a, 12b, or the like. The QAP 14 sends a message 304 including allocation information for assigning resources, (e.g., a certain time, sub-carriers or antennas), for the connection based on the requirements and indicate what is available. A direct communication link is then established 306 between the QSTAs 12a and 12b.

[0038] The allocation information in the message 304 is sent to the QSTA 12a and QSTA 12b. The other QSTAs 12c-12f may also be informed of the direct communication link 306 so that they are aware of the resource being in use. The QSTAs 12c-12f can be informed by broadcasting the message 304 to all of the QSTAs 12a-12f or by requiring all QSTAs 12a-12f to monitor the QAP 14 for the message 304, even if it is not intended for their use. This may prevent other QSTAs 12a - 12f from using the same resources.

[0039] Although the features and elements of the present invention are described in the preferred embodiments in particular combinations, each feature or element can be used alone without the other features and elements of the preferred embodiments or in various combinations with or without other features and elements of the present invention.

EMBODIMENTS

1. In a wireless communication system including at least one access point (AP) and a plurality of stations (STAs), a method comprising:

(a) a first STA sending a direct link setup (DLS) request to an AP for setting up a direct communication link to a second STA;

(b) the AP forwarding the DLS request to the second STA;

(c) the second STA sending a response to the AP either accepting or rejecting the DLS request;

(d) the AP determining whether or not to accept the DLS request; and

(e) the AP sending a DLS response to the first STA, whereby the first STA and the second STA directly communicate with each other over a direct communication link if the DLS request is accepted.

2. The method of embodiment 1 wherein the determination of step (d) is based on the strength of signals exchanged between the first and second STAs.

3. The method of embodiment 1 wherein the determination of step (d) is based on the current load activity of the AP.

4. The method of embodiment 1 wherein the determination of step (d) is based on the capability of the first and second STAs.

5. The method of embodiment 1 wherein the determination of step (d) is based on the quality of a channel over which data packets are exchanged between the first and second STAs.

6. The method of embodiment 5 wherein the channel quality is determined by exchanging packets between the first and second STAs before a DLS is implemented.

7. The method of embodiment 1 wherein the determination of step (d) is based on an interference level of a channel over which data packets are exchanged between first and second STAs.

8. The method of embodiment 1 wherein the DLS request includes at least one of a rate set, capabilities of the first STA, and medium access control (MAC) addresses of the first STA and the second STA.

9. The method of embodiment 1 further comprising:

(f) the AP sending a measurement request to the first STA for measuring a channel condition between the first STA and the second STA;

(g) the first STA sending a response with a measurement result, whereby the AP determines whether or not accept the DLS request based on the measurement result.

10. The method of embodiment 1 further comprising:

(f) the first STA sending a message to the AP for searching the second STA before the first STA sends the DLS request to the AP, whereby the first STA sends the DLS request to the AP only if the first STA receives relevant information of the second STA from the AP.

11. The method of embodiment 1 wherein the first STA includes an optimal rate and channel quality information between the first STA and the second STA in the DLS request.

12. The method of embodiment 11 wherein the information is obtained from a previous transmission between the first STA and the second STA.

13. The method of embodiment 11 wherein the information is obtained by monitoring transmissions from the second STA.

14. The method of embodiment 1 wherein the AP is configured to reject the DLS request if the AP can provide a higher overall throughput between the first and second STAs by facilitating transmission via the AP instead of allowing direct communication between the first and second STAs.

15. The method of embodiment 1 wherein the AP is configured to reject the DLS request if the quality of the communication link between the first and second STAs is degraded.

16. The method of embodiment 1 wherein the AP is configured to reject the DLS request to secure communications between the first and second STAs.

17. The method of embodiment 1 wherein the AP is capable of sending a DLS response message to a selected one of the first and second STAs.

18. The method of embodiment 17 wherein the DLS response message includes an action frame for DLS teardown having a timer information field, and the selected STA must respond back to the AP with a DLS teardown message before the timer expires in order to initiate DLS teardown.

19. The method of embodiment 1 wherein each of the first and second STAs includes a timer, and each of the first and second STAs is configured to initiate a DLS teardown carried out by the AP before the timer expires.

20. The method of embodiment 19 wherein the timer is reset in response to receiving a packet.

21. The method of embodiment 1 wherein the first STA sends a measurement packet to the second STA and the AP before DLS is implemented to improve a data rate and a packet error rate.

22. The method of embodiment 21 wherein the measurement packet is one of a channel quality indicator (CQI), a received signal strength indication (RSSI) or an interference measurement.

23. In a wireless communication system including a plurality of stations (STAs), a method for peer-to-peer communication in the wireless communication system, the method comprising:

(a) each STA maintaining a database of one-hop STAs and two-hop STAs, the one-hop STA being a STA that can monitor the other STAs and the two-hop

STA being a STA that cannot hear the other STAs directly but is associated with a one-hop STA; and

(b) STAs that want to communicate with each other sending a message to their one-hop STAs regarding a desired communication between STAs, whereby the communication between the STAs is not disrupted by neighboring STA transmissions.

24. The method of embodiment 23 further comprising:

(c) a new STA joining the system sending a request message to neighboring STAs;

(d) existing STAs sending a response to the new STA with necessary information; and

(e) the new STA utilizing the information to initiate a communication with other STAs.

25. The method of embodiment 24 wherein the information includes at least one of bandwidth, a frequency band, sub-carrier information, multiple-input multiple-output (MIMO) related information, a received signal strength indication (RSSI), interference, medium access control (MAC) address, service capability and other information about the STA sending the response.

26. The method of embodiment 24 wherein the new STA scans a channel and sends the request message directed to a particular STA.

27. In a wireless communication system including at least one access point (AP) and a plurality of stations (STAs), a method for peer-to-peer communication in the wireless communication system, the method comprising:

(a) each STA maintaining a database of STAs that each STA can directly communicate with and STAs that each STA can communicate with through an AP;

(b) a first STA sending a request message to the AP for communication with a second STA;

(c) the AP determining whether to permit communication between the first STA and the second STA directly or through the AP; and

(d) the AP sending a response message for assigning a resource for supporting the communication.

28. The method of embodiment 27 wherein the AP sends the response message to the first STA and the second STA.

29. The method of embodiment 27 wherein the response message is broadcast whereby all other STAs are informed about the resource assignment.

30. The method of embodiment 27 wherein the AP implements a DLS to establish a direct communication link between the first and second STAs.

31. The method of embodiment 30 wherein a DLS is implemented if the channel quality is better between the first and second STAs when they communicate over the direct communication link than when they communicate via the AP.

32. A wireless communication system comprising:

(a) at least one access point (AP);

(b) a first station (STA); and

(c) a second STA, wherein (i) the first STA sends a direct link setup (DLS) request to the AP for setting up a direct communication link to the second STA, (ii) the AP forwards the DLS request to the second STA, (iii) the second STA sends a response to the AP either accepting or rejecting the DLS request, (iv) the AP determines whether or not to accept the DLS request, and (v) the AP sends a

DLS response to the first STA, whereby the first STA and the second STA directly communicate with each other if the DLS request is accepted.

33. The system of embodiment 32 wherein the determination as to whether or not to accept the DLS request is based on the strength of signals exchanged between the first and second STAs.

34. The system of embodiment 32 wherein the determination as to whether or not to accept the DLS request is based on the current load activity of the AP.

35. The system of embodiment 32 wherein the determination as to whether or not to accept the DLS request is based on the capability of the first and second STAs.

36. The system of embodiment 32 wherein the determination as to whether or not to accept the DLS request is based on the quality of a channel over which data packets are exchanged between the first and second STAs.

37. The system of embodiment 36 wherein the channel quality is determined by exchanging packets between the first and second STAs before a DLS is implemented.

38. The system of embodiment 32 wherein the determination as to whether or not to accept the DLS request is based on an interference level of a channel over which data packets are exchanged between first and second STAs.

39. The system of embodiment 32 wherein the DLS request includes at least one of a rate set, capabilities of the first STA, and medium access control (MAC) addresses of the first STA and the second STA.

40. The system of embodiment 32 wherein the AP sends a measurement request to the first STA for measuring a channel condition between the first STA and the second STA and the first STA sends a response with a measurement result, whereby the AP determines whether or not accept the DLS request based on the measurement result.

41. The system of embodiment 32 wherein the first STA sends a message to the AP for searching the second STA before the first STA sends the DLS request to the AP, and the first STA sends the DLS request to the AP only if the first STA receives relevant information of the second STA from the AP.

42. The system of embodiment 32 wherein the first STA includes an optimal rate and channel quality information between the first STA and the second STA in the DLS request.

43. The system of embodiment 42 wherein the information is obtained from a previous transmission between the first STA and the second STA.

44. The system of embodiment 42 wherein the information is obtained by monitoring transmissions from the second STA.

45. The system of embodiment 32 wherein the AP is configured to reject the DLS request if the AP can provide a higher overall throughput between the first and second STAs by facilitating transmission via the AP instead of allowing direct communication between the first and second STAs.

46. The system of embodiment 32 wherein the AP is configured to reject the DLS request to secure communications between the first and second STAs.

47. The system of embodiment 32 wherein each of the first and second STAs include a timer, and each of the first and second STAs is configured to initiate a DLS teardown carried out by the AP before the timer expires.

48. The system of embodiment 47 wherein the timer is reset in response to receiving a packet.

49. The system of embodiment 32 wherein the first STA sends a measurement packet to the second STA and the AP before DLS is implemented to improve a data rate and a packet error rate.

50. The system of embodiment 49 wherein the measurement packet is one of a channel quality indicator (CQI), a received signal strength indication (RSSI) or an interference measurement.

51. In a wireless communication system including at least one access point (AP) and a plurality of stations (STAs), a method comprising:

(a) the AP sending a direct link setup (DLS) initiate message to a first STA and a second STA for setting up a direct communication link between the first and second STAs;

(b) each of the first and second STAs sending a DLS request message to the AP, each DLS request message indicating whether the DLS initiate message is accepted or rejected by the respective STA; and

(c) the AP sending a DLS response message to each of the first and second STAs to initiate a data transfer over a communication link between the first and second STAs if both of the DLS request messages indicate that the DLS initiate request is accepted.

52. The method of embodiment 51 wherein the DLS initiate message includes an action frame used by the AP to initiate a DLS setup between two STAs.

53. The method of any one of embodiments 51 and 52 wherein the DLS initiate message is configured to allow a STA to respond thereto.

54. The method of any one of embodiment 51-53 wherein the DLS response message is configured to allow the AP to initiate a DLS between two STAs.

55. The method of embodiment 51 wherein the DLS initiate message includes an action frame having a timer information field.

56. The method of embodiment 55 wherein each of the STAs must respond back to the AP with a DLS request message before the timer expires to initiate a DLS between the STAs.

* * *

CLAIMS

What is claimed is:

1. A method for use in an access point (AP) for establishing a direct link setup (DLS), the method comprising:

receiving, from a first station (STA), a DLS request for establishing a direct communication link with a second STA, the DLS request including a high throughput (HT) capabilities element that indicates an antenna technology of the first STA; and

transmitting a DLS response indicating a DLS grant and an indication of the HT capabilities of the second STA.

2. The method of claim 1, wherein the DLS request includes at least one of a rate set and medium access control (MAC) addresses of the first STA and the second STA.

3. The method of claims 1 or 2, further comprising:

receiving a measurement request for measuring a channel condition; and

transmitting a response that includes a measurement result from the AP.

4. The method of anyone of the preceding claims further comprising:

initiating a DLS teardown in response to a timer expiring.

5. The method of claim 4, further comprising:

resetting the timer in response to receiving a packet.

6. An access point (AP) configured to establish a direct link setup (DLS), the AP comprising:

a receiver configured to receive a DLS request from a station (STA) to establish a direct communication link with a remote STA, the DLS request including a high throughput (HT) capabilities element that indicates an antenna technology of the STA; and

a transmitter configured to transmit a DLS response that indicates a DLS grant and an indication of the HT capabilities of the remote STA.

7. The AP of claim 6, wherein the receiver is configured to receive a DLS request that includes at least one of a rate set and medium access control (MAC) addresses of the STA and the remote STA.

8. The AP of claims 6 or 7, wherein the transmitter is further configured to transmit a measurement request for measuring a channel condition; and

the receiver is further configured to receive a response with a measurement result.

9. The AP of any one of claims 6 to 8 further comprising:

a timer configured to initiate a DLS teardown in response to the timer expiring.

10. The AP of claim 9, wherein the timer is configured to be reset in response to receiving a packet.