

METHOD AND APPARATUS FOR PROTECTING HIGH THROUGHPUT STATIONS

[0001] FIELD OF INVENTION

[0002] The present invention relates to wireless communication systems. More particularly, the present invention is related to the protection of high throughput (HT) transmissions in the presence of other incompatible HT transmissions and legacy transmissions.

[0003] BACKGROUND

[0004] HT transmissions need protection from legacy stations (STAs), since legacy STAs using contention will not be able to decipher HT physical layer (PHY) packet data units (PPDUs), and thus the legacy STAs may not interpret the medium as being busy. Similarly, HT transmissions of a given HT STA require protection from other HT STAs in the case where the HT PHYs are incompatible.

[0005] As shown in Figure 1, each legacy PPDU 100 comprises a legacy PHY preamble/header 105 followed by a legacy PHY payload 110, which is typically a medium access control (MAC) packet data unit (PDU). As an example, Figures 2A and 2B show that an HT device (i.e., Type A) and another HT device (i.e., Type B) have different PHY preambles 115, 120. The Type A device has both a legacy preamble 105 as well as a new preamble 115 for MIMO capability as part of a PHY header, whereas, the Type B device only has a new PHY preamble 120. However, the Type B device can decode the legacy preamble 105. The HT PHY preambles 115, 120 of both the Type A and B devices are different. In this case, the two devices will not be able to communicate with each other. Also, the Type A device is inefficient in absence of any legacy devices. Two considered scenarios (1 and 2) are described below.

[0006] Scenario 1 uses at least three different types of devices which operate

with different/incompatible PHY layers: 1) legacy devices which transmit packets with only a legacy preamble 105, as shown in Figure 1; 2) HT Type A devices which transmit PPDU's with Type A HT preambles 115, as shown in Figure 2A; and 3) HT Type B devices which transmit PPDU's with Type B HT preambles 120, as shown in Figure 2B.

[0007] Scenario 2 also uses at least three types of devices: 1) legacy devices which transmit packets with just a legacy preamble 105, as shown in Figure 1; 2) HT devices which transmit mixed-mode packets, (e.g., a PHY preamble comprising a legacy preamble and an HT preamble), as shown in Figure 2C; and 3) HT devices which transmit packets with just HT PHY preambles, (i.e., a Green Field (GF) PHY preamble 120 and HT preamble 115), as shown in Figure 2D.

[0008] Thus, different types of HT devices may operate using mutually incompatible PHY layers. For example, the receiver of a first type of HT STA may not be able to decode packets transmitted by a second type of HT STA, and vice versa.

[0009] SUMMARY

[0010] The present invention proposes enhancements that provide HT and legacy inter-working solutions for different schemes implemented in a wireless communication network including a plurality of STAs, such as those schemes used in IEEE 802.11n, or the like. The interworking solutions include MAC and PHY layer protection mechanisms, preamble signaling, and beacon signaling. In one embodiment, a first type of HT STA is identified by a second type of HT STA by using bits in the preamble of a packet to indicate which PHY type will be used in the remaining portion of the packet. In another embodiment, a second type of HT STA sends ready-to-send (RTS)/clear-to-send (CTS) or CTS-to-self for reserving the medium in the presence of a first type of HT STA. In yet another embodiment, legacy preamble protection is used by different types of HT STAs for protecting their transmissions. In yet another embodiment, an access point indicates

operation or support in a system for a legacy preamble using a beacon or an association message.

[0011] BRIEF DESCRIPTION OF THE DRAWINGS

[0012] A more detailed understanding of the invention may be had from the following description, given by way of example and to be understood in conjunction with the accompanying drawings wherein:

[0013] Figure 1 illustrates a conventional legacy PPDU which includes a legacy preamble and a legacy PHY payload;

[0014] Figures 2A and 2B illustrate a first conventional scenario (Scenario 1) in which HT Type A and HT Type B devices operate with different and incompatible physical layers;

[0015] Figure 2C and 2D illustrate a second conventional scenario (Scenario 2) in which HT devices transmit mixed-mode packets and/or packets with only HT PHY preambles;

[0016] Figures 3A and 3B illustrate PPDU structures which use an HT preamble including bits which indicate the HT type of a PHY payload in accordance with the present invention;

[0017] Figure 4 is a block diagram of a STA configured to receive, decipher and transmit protected HT transmissions using a legacy preamble in accordance with the present invention;

[0018] Figure 5 is a block diagram of an AP configured to transmit a beacon or association message which include a capability information element (IE) in accordance with the present invention;

[0019] Figure 6 shows the fields of the capability IE included in the beacon or association message transmitted by the AP of Figure 5; and

[0020] Figure 7 shows a wireless communication system including the AP of Figure 5 and a plurality of HT STAs similar to the HT STA of Figure 4.

[0021] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] When referred to hereafter, the terminology "STA" includes but is not limited to a wireless transmit/receive unit (WTRU) , a user equipment (UE), 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 "access point (AP)" includes but is not limited to a base station, a Node-B, a site controller or any other type of interfacing device in a wireless environment.

[0023] 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.

[0024] The present invention allows the interoperability of HT devices which operate using different/incompatible PHY layers such as those previously described with respect to Scenario 1 and/or Scenario 2, as shown in Figures 1 and 2. MAC and PHY level protection techniques are used to resolve the interoperability problems introduced by incompatible PHY payloads. In addition, signaling in the HT preamble is implemented to facilitate interoperability. Finally, beacon signaling is used to help support the interoperability features.

[0025] In one embodiment illustrated by Figures 3A and 3B, a preamble structure of a PPDU, (i.e., packet), is used for both HT STAs of Type A and B, whereby the HT preambles include bits indicating which PHY payload Type will be used in remaining portion of the packet. Each of the HT STAs is able to decode the legacy preamble 105 using a receiver configured to decode the PHY preamble which is sent at a basic rate/modulation. The HT PHY preamble provides information about the modulation and coding scheme (MCS) or PHY payload type used for the remaining portion of the packet. However, it may not be possible to decode the remaining portion of the packet since the PHY layer transmission is incompatible, (e.g., space-time block code (STBC) transmissions are not compatible with non-STBC PHY transmissions). The first HT STA will not have a problem in decoding both the PHY preambles. However, the second HT STA will be able to decode the

legacy preamble and the bit indicating the PHY payload type used for the remaining portion, (i.e., payload), of the packet.

[0026] The second HT STA will be able to decode the rest of the packet. However, even if the rest of the packet is not decoded, the second HT STA will extract sufficient information from the legacy PHY preamble to set its NAV timer for the remainder of the transmission. Also, in this embodiment, the first HT STA is able to identify the second HT STA preamble based on certain bits in the PHY preamble, and decode the remainder of the packet.

[0027] In a MAC level protection mechanism, MAC layer signaling is used to set a network allocation vector (NAV), which is a MAC level carrier-sense procedure. The MAC signaling could be implemented by using RTS/CTS or CTS-to-self mechanisms before transmission, to set the NAV in the system, or by simply appropriately setting a duration field in the MAC header of a transmitted packet.

[0028] In a PHY level protection mechanism, the legacy PHY layer convergence procedure (PLCP) rate and length fields in a legacy signal field are set to indicate a desired duration for protection. The legacy signal field precedes the HT part of the PPDU. The legacy signal field is transmitted using an omnidirectional antenna pattern and a legacy MCS such that it may be received by all STAs. This method of protection is called legacy signal (L-SIG) field transmit opportunity (TXOP) protection.

[0029] In a second embodiment (applying to Scenario 1 and scenario 2), the second HT STA (HT Type B device) sends RTS/CTS or CTS-to-self for reserving the medium in the presence of the first HT STA, (HT Type A device).

[0030] In another embodiment (applied to both Scenarios 1 & 2), a preferable network AP supports a legacy preamble, the HT STA preambles and a MAC packet transmission with HT protection mechanisms according to the above proposed methods. Alternatively, if the AP does not support the HT STAs, it indicates this information in a beacon or in an association message. Hence, the HT STAs operate in legacy mode using a legacy preamble.

[0031] The legacy signal field, (PLCP rate and length fields), may be used to indicate the entire period for protection, and may be sent aperiodically when required. The legacy preamble can be sent with and without an actual MAC packet following it. This does not require sending the legacy signal field with every packet in the protected duration. This also avoids the overhead of transmitting legacy packets, (MAC level), for protection of HT transmissions. Furthermore, the first HT STA, (HT STA type A of Scenario 1), does not send the PHY preamble in the absence of legacy station. The information sent on the beacon can be used by the first HT STA of Type A as in Scenario 1 to find out whether there are legacy STAs in the network.

[0032] Figure 4 is a block diagram of an HT STA 400 configured to receive, decipher and transmit HT transmissions using a legacy preamble in accordance with the present invention. The HT STA 400 includes a processor 405, a transmitter 410, a receiver 415 and an antenna 420 electrically coupled to the transmitter 410 and the receiver 415. The processor 405 is configured to generate and decipher protected HT transmissions in accordance with the present invention, whereby a legacy preamble precedes the HT transmissions having a preamble with bits indicating the PHY payload type.

[0033] Figure 5 is a block diagram of an AP 500 configured to protect HT transmissions using a legacy preamble in accordance with the present invention. The AP 500 includes a processor 505, a transmitter 510, a receiver 515 and an antenna 520 electrically coupled to the transmitter 510 and the receiver 515. The processor 505 is configured to generate a beacon or an association message for transmission by the transmitter 510 via the antenna 520. The beacon or association message may include information which indicates operation or support for a legacy preamble, HT STA preambles and a MAC packet transmission with HT protection mechanisms according to the above proposed methods.

[0034] Figure 6 shows the fields of a capability Information Element (IE) included in the beacon or association message transmitted by the AP 500 which

indicate support for the HT protection mechanisms. The order of the fields is not significant and can be arbitrarily specified for a given implementation. The fields may be included in a new capability IE, or added to existing capability IEs.

[0035] Figure 7 shows a wireless communication system 700 including the AP 500 of Figure 5 and a plurality of HT STAs 400₁ - 400_N, similar to the HT STA 400 (PHY Type B) of Figure 4. If HT PHY Type B protection with an RTS/CTS or CTS-to-self subfield indicates support of this mechanism in beacons transmitted by the AP 500, one of the HT STAs 400 may start a TXOP by transmitting an RTS message to the AP 500. The AP 500 then responds to the RTS message by transmitting a CTS message. The HT STA 400 and the AP 500 may also use a CTS-to-self message for protecting HT transmissions of PHY Type B.

[0036] Embodiments

1. A high throughput (HT) transmission method implemented in a wireless communication system including a first type of station (STA) and a second type of STA, the method comprising:

the first STA transmitting at least one HT physical layer (PHY) packet data unit (PPDU), the PPDU including an HT preamble and an HT PHY payload, the HT preamble including information associated with the HT PHY payload;

the second STA receiving the PPDU from the first STA; and

the second STA extracting the information associated with the HT PHY payload from the HT preamble without being able to decode the HT PHY payload.

2. The method of embodiment 1 wherein the HT PPDU transmitted by the first STA includes a legacy PHY preamble, the method further comprising:

the second STA setting a network allocation vector (NAV) timer for the transmission based on information included in the legacy PHY preamble.

3. The method as in one of embodiments 1 and 2 wherein the HT PPDU transmitted by the first STA includes a legacy PHY preamble, the method further comprising:

the second STA setting a network allocation vector (NAV) timer for the transmission based on at least one bit included in the HT preamble.

4. A method as in one of embodiments 1-3 wherein the first and second STAs participate in a wireless communication, wherein PPDU's transmitted by the first STA are incompatible with the capabilities of the second STA.

5. The method as in one of embodiments 1-4 further comprising:
the second STA identifying the first STA.

6. The method as in one of embodiments 1-4 further comprising:
the second STA decoding the entire PPDU.

7. The method as in one of embodiments 1-4 further comprising:
the first STA identifying the second STA.

8. The method as in one of embodiments 1-7 wherein the second STA sends a request to an access point (AP) to send a (RTS)/clear-to-send (CTS) message or to provide CTS-to-self protection support for reserving a medium.

9. The method as in one of embodiments 1-7 wherein the second STA is in the presence of at least one first STA in the system.

10. A method as in embodiment 8 wherein the RTS/CTS or the CTS-to-self protection support is indicated in a beacon transmitted by the AP.

11. A high throughput (HT) station (STA) comprising:
a transmitter for transmitting protected HT transmissions;
a processor for generating at least one HT physical layer (PHY) packet data unit (PPDU), the PPDU including an HT preamble and an HT PHY payload, the HT preamble including information associated with the HT PHY payload; and
a receiver for decoding legacy PHY preambles received from other HT STAs.

12. The HT STA of embodiment 11 wherein a network allocation vector (NAV) timer for the transmission is set based on information included in the legacy PHY preamble.

13. The HT STA of embodiment 11 wherein a network allocation vector (NAV) timer for the transmission is set based on at least one bit included in the HT preamble.

14. The HT STA of embodiment 11 wherein the receiver decodes both mixed-mode PPDU's and non-HT PPDU's.

15. The HT STA of embodiment 11 wherein the receiver decodes both Green Field mode PPDU's, mixed-mode PPDU's and non-HT format PPDU's.

16. A method of protecting high throughput (HT) transmissions, the method comprising:

a non-access point (non-AP) station (STA) initiating a transmit opportunity (TXOP) by transmitting a request signal including a ready-to-send (RTS) frame to an access point (AP); and

the AP responding to the non-AP STA with a response clear-to-send (CTS) frame.

17. The method of embodiment 16 wherein the non-AP STA and the AP use a CTS-to-self message for protecting HT transmissions.

18. An access point (AP) comprising:

a processor configured to generate an association message, wherein the association message includes a capability information element (IE) having a plurality of fields which indicate operation or support for a legacy preamble, high throughput (HT) station (STA) preambles and a medium access control (MAC) packet transmission with HT protection mechanisms;

an antenna; and

a transmitter electrically coupled to the processor and the antenna for transmitting the association message.

19. An access point (AP) comprising:

a processor configured to generate a beacon, wherein the beacon includes a capability information element (IE) having a plurality of fields which indicate

operation or support for a legacy preamble, high throughput (HT) station (STA) preambles and a medium access control (MAC) packet transmission with HT protection mechanisms;

an antenna; and

a transmitter electrically coupled to the processor and the antenna for transmitting the beacon.

[0037] 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.

*

*

*

What is claimed is:

1. A method for use in a wireless station (STA), characterized in that the method comprises:
receiving a message containing a legacy preamble, a high throughput, HT, physical layer, PHY, preamble (305), and a HT payload, wherein the HT PHY preamble (305) contains a bit that indicates whether the HT payload is space-time block code (STBC) modulated; and
decoding the HT PHY preamble and the HT payload.
2. The method of claim 1 further comprising:
setting a network allocation vector, NAV, timer for the message based on information included in the legacy preamble.
3. The method of claim 1 further comprising:
setting a network allocation vector, NAV, timer for the message based a bit included in the HT PHY preamble.
4. The method of claim 1 further comprising:
transmitting a request to an access point, AP (500), for a ready-to-send/clear-to-send, RTS/CTS, message or to provide CTS-to-self protection support.
5. The method of claim 4 wherein the HT PHY preamble includes a bit that identifies a HT STA (400₁) from which the message was received.
6. A method as in claim 4 further comprising: receiving a beacon from an access point (AP), wherein the beacon indicates RTS/CTS or the CTS-to-self protection support.

7. A high throughput, HT, station, STA (400), comprising: a processor (405) configured to generate a message containing a legacy preamble, a HT physical layer, PHY, preamble, and a HT payload, wherein the HT PHY preamble contains a bit that indicates whether the HT payload is space-time block code (STBC) modulated;

a transmitter configured to transmit the generated message; and

a receiver (415) configured to decode legacy PHY preambles received from other HT STAs.

8. The HT STA (400) of claim 7 wherein the processor is configured to set a network allocation vector, NAV, timer for the message based on information included in the legacy preamble.

9. The HT STA (400) of claim 7 wherein the processor is configured to set a network allocation vector, NAV, timer for the message based on a bit included in the HT PHY preamble.

10. A high throughput (HT) station (STA) comprising:

a receiver configured to receive a message that contains a legacy preamble, a HT PHY preamble, and a HT payload, wherein the HT PHY preamble contains a bit that indicates whether the HT payload is space-time block code (STBC) modulated, and decode the HT PHY preamble and the HT payload.

11. The STA of claim 10, wherein the legacy preamble includes a field that indicates a packet duration.

12. The method of claim 1, wherein the legacy preamble includes a field that indicates a packet duration.

13. The STA of claim 7, wherein the legacy preamble includes a field that indicates a packet duration.