individually addressed robust management frames and group addressed management frames.

SUMMARY

[0004a] In a first aspect, the present disclosure provides a transmitting multi-link device (MLD) comprising: circuitry, which in operation, constructs an Additional Authentication Data (AAD) and a Nonce and encapsulates a plaintext MAC protocol data unit (MPDU), the AAD and the Nonce to generate an encapsulated MPDU, wherein the AAD includes an Address 1 (A1) field to which a recipient MLD's medium access control (MAC) address is set, an Address 2 (A2) field to which the transmitting MLD's MAC address is set, and wherein the Nonce includes an Address 2 (A2) field to which the transmitting MLD's MAC address is set; and a transmitter, which in operation, transmits the encapsulated MPDU to the recipient MLD on a first link.

[0004b] In a second aspect, the present disclosure provides a communication method for a transmitting multi-link device (MLD), the communication method comprising: constructing an Additional Authentication Data (AAD) and a Nonce; encapsulating a plaintext MAC protocol data unit (MPDU), the AAD and the Nonce to generate an encapsulated MPDU, wherein the AAD includes an Address 1 (A1) field to which a recipient MLD's medium access control (MAC) address is set, and an Address 2 (A2) field to which the transmitting MLD's MAC address is set, and wherein the Nonce includes an Address 2 (A2) field to which the transmitting MLD's MAC address is set; and transmitting the encapsulated MPDU to the recipient MLD on a first link.

[0005] One non-limiting and exemplary embodiment facilitates providing a first multi-link device (MLD) configured to operate with a first plurality of affiliated stations, comprising: circuitry, which in operation, sets up a robust security network association

(RSNA) with a second MLD that is configured to operate with a second plurality of affiliated STAs, wherein two or more links have been established between STAs of the first plurality of affiliated STAs and corresponding STAs of the second plurality of affiliated STAs, wherein the circuitry constructs an Additional Authentication Data (AAD) and a Nonce that are used for cryptographical encapsulation of a MAC protocol data unit (MPDU) to form an encapsulated MPDU, wherein the AAD includes an Address 1 (A1) field, an Address 2 (A2) field, an Address 3 (A3) field and a Sequence Control (SC) field, and the Nonce includes an A2 field, wherein the SC field of the AAD is based on a SC field of the MPDU, and a transmitter, which in operation, transmits the encapsulated MPDU to the second MLD on a first link as an initial transmission, and upon failure of the initial transmission, retransmits the encapsulated MPDU on a second link without reperforming the cryptographical encapsulation.

[0006] Another non-limiting and exemplary embodiment facilitates providing a method for retransmission of a MPDU in a multi-link communication, comprising: setting up, at a first MLD, a robust security network association (RSNA) with a second MLD that is configured to operate with a second plurality of affiliated STAs, wherein two or more links have been established between STAs of the first plurality of affiliated STAs and corresponding STAs of the second plurality of affiliated STAs; constructing

CLAIMS

1. A ~~first~~ transmitting multi-link device (MLD) ~~configured to operate with a first plurality of affiliated STAs,~~ comprising:

circuitry, which in operation, ~~sets up a robust security network association (RSNA) with a second MLD that is configured to operate with a second plurality of affiliated STAs, wherein two or more links have been established between STAs of the first plurality of affiliated STAs and corresponding STAs of the second plurality of affiliated STAs, wherein the circuitry~~ constructs an Additional Authentication Data (AAD) and a Nonce ~~that are used for cryptographical~~and encapsulat~~es~~~~ion of~~ a plaintext MAC protocol data unit (MPDU), the AAD and the Nonce to ~~form~~ generate an encapsulated MPDU, wherein the AAD includes an Address 1 (A1) field to which a recipient MLD's medium access control (MAC) address is set, an Address 2 (A2) field to which the transmitting MLD's MAC address is set, ~~an Address 3 (A3) field and a Sequence Control (SC) field,~~ and wherein the Nonce includes an Address 2 (A2) field to which the transmitting MLD's MAC address is set~~, wherein the SC field of the AAD is based on a SC field of the MPDU,~~; and

a transmitter, which in operation, transmits the encapsulated MPDU to the ~~second~~ recipient MLD on a first link ~~as an initial transmission, and upon failure of the initial transmission, retransmits the encapsulated MPDU on a second link without reperforming the cryptographical encapsulation~~.

2. The ~~first~~ transmitting MLD according to claim 1, wherein if the transmission of the encapsulated MPDU is unsuccessful, the transmitter retransmits the MPDU on another link without encapsulating the MPDU with a new packet number (PN)~~the A2 field of the AAD and the Nonce is set to a medium access control (MAC) address~~

~~that identifies the first MLD, and wherein the A1 field of the AAD is set to a MAC address that identifies the second MLD~~.

3. The ~~first~~ transmitting MLD according to claim 1, wherein ~~the A3 field of the AAD is set to a MAC address that identifies an Access Point (AP) MLD, wherein the AP MLD is the first or second MLD~~ a common packet number (PN) is used for initial transmission on the first link and retransmission on another link.

4. The ~~first~~ transmitting MLD according to claim 1, ~~wherein the circuitry specifies in the MPDU settings of the A1, A2, A3 fields, the settings indicating whether, during cryptographical decapsulation of the retransmitted MPDU, the A1, A2, A3 fields are to be set to a MAC address that identifies the second MLD, a MAC address that identifies the first MLD and a MAC address that identifies an AP MLD respectively, or the A1, A2, A3 fields are to be set to a MAC address of an affiliated STA of the second MLD, a MAC address of an affiliated STA of the first MLD and the MAC address that identifies the AP MLD respectively, or the A1, A2, A3 fields are to be set to A1, A2, A3 fields of the MPDU respectively, wherein the AP MLD is the first or second MLD~~ comprising a first plurality of affiliated STAs that are capable of establishing one or more links with a second plurality of affiliated STAs associated with the recipient MLD.

5. The ~~first~~ transmitting MLD according to claim 3, wherein the settings of the A1~~,~~ and A2~~, A3~~ fields are indicated in one of a Counter Mode Cipher Block Chaining Message Authentication Code Protocol (CCMP) Header field or a Galois/Counter Mode Protocol (GCMP) Header field of the encapsulated MPDU.

6. The ~~first~~ transmitting MLD according to claim 1, wherein ~~the A2 field of the AAD and the Nonce are set to an A2 field of the MPDU, and the A1 field of the AAD is set to an A1 field of the MPDU, wherein upon failure of the initial transmission, the circuitry further specifies in the retransmitted MPDU settings of the A1, A2, A3 fields, the settings indicating whether, during cryptographical decapsulation of the retransmitted MPDU, the A1, A2, A3 fields are to be set to MAC addresses of an affiliated STA of the second MLD and an affiliated STA of the first MLD respectively, or the A1, A2, A3 fields are to be set to the A1, A2, A3 fields of the retransmitted MPDU respectively~~ a common packet number (PN) is used for transmission and retransmission on a plurality of links.

7. The ~~first~~ transmitting MLD according to claim 1, wherein one of a Counter Mode Cipher Block Chaining Message Authentication Code Protocol (CCMP) or a Galois Counter Mode Protocol (GCMP) is used to cryptographically protect the MPDU.

8. The ~~first~~ transmitting MLD according to claim 1, wherein ~~the MPDU comprises identification information of the first and second MLDs, wherein the A2 field of the AAD and the Nonce is set to a MAC address that identifies the first MLD indicated in the identification information, and the A1 field of the AAD is set to a MAC address that identifies the second MLD indicated in the identification information~~ the control circuity, in operation, maintains a single packet number (PN) space for a plurality of links.

~~9. A first multi-link device (MLD) configured to operate with a first plurality of affiliated STAs, comprising:~~

~~circuitry, which in operation, sets up a robust security network association (RSNA) with a second MLD that is configured to operate with a second plurality of affiliated STAs, wherein two or more links have been established between STAs of the first plurality of affiliated STAs and corresponding STAs of the second plurality of affiliated STAs, and~~

~~a receiver, which in operation, receives a cryptographically encapsulated MAC protocol data unit (MPDU) from the second MLD, wherein the circuitry constructs an Additional Authentication Data (AAD) and a Nonce that are used for cryptographical decapsulation of the received MPDU, wherein the AAD includes an Address 1 (A1) field, an Address 2 (A2) field, an Address 3 (A3) field and a Sequence Control (SC) field, and the Nonce includes an Address 2 (A2) field, wherein the A2 field of the AAD and the Nonce may be set to either an A2 field of the MPDU or a medium access control (MAC) address that identifies the second MLD or a MAC address of one of the second plurality of affiliated STAs, the A1 field of the AAD may be set to either an A1 field of the MPDU or a MAC address that identifies the first MLD or a MAC address of one of the first plurality of affiliated STAs, the A3 field of the AAD may be set to either an A3 field of the MPDU or a MAC address that identifies either the first or the second MLD that acts as an access point MLD and the SC field of the AAD is based on a SC field of the MPDU.~~

~~10. The first MLD according to claim 9, wherein the circuitry cryptographically decapsulates the MPDU received from the second MLD, wherein the A2 field of the~~

~~AAD and the Nonce is set to the MAC address that identifies the second MLD, and the A1 field of the AAD is set to the MAC address that identifies the first MLD.~~

~~11. The first MLD according to claim 9, wherein the circuitry cryptographically decapsulates the received MPDU based on settings of the A1, A2, A3 fields indicated in the MPDU, the settings indicating whether, during the cryptographical decapsulation, the A1, A2, A3 fields are to be set to the MAC address that identifies the first MLD, the MAC address that identifies the second MLD and a MAC address that identifies an AP MLD respectively, or the A1, A2, A3 fields are to be set to the MAC address of an affiliated STA of the first MLD, the MAC address of an affiliated STA of the second MLD and the MAC address that identifies the AP MLD respectively, or the A1, A2, A3 fields are to be set to the A1, A2, A3 fields of the MPDU respectively, wherein the AP MLD is the first or second MLD.~~

~~12. The first MLD according to claim 11, wherein the settings of the A1, A2, A3 fields are indicated in one of a CCMP Header or a GCMP Header of the MPDU received from the second MLD.~~

~~13. The first MLD according to claim 9, wherein the circuitry cryptographically decapsulates a first MPDU received from the second MLD by setting the A2 field of the AAD and the Nonce to the A2 field of the first MPDU, and the A1 field of the AAD to the A1 field of the first MPDU, wherein the first MPDU includes a Retry subfield that is set to 0; and wherein the circuitry cryptographically decapsulates a second MPDU received from the second MLD based on the settings of the A1, A2, A3 fields indicated in the second MPDU, the settings indicating whether, during the~~

~~cryptographical decapsulation, the A1, A2, A3 fields are to be set to the MAC address of an affiliated STA of the first MLD, the MAC address of an affiliated STA of the second MLD and a MAC address that identifies an AP MLD respectively, or the A1, A2, A3 fields are to be set to A1, A2, A3 fields of the second MPDU respectively, wherein the second MPDU includes a Retry subfield that is set to 1, and wherein the AP MLD is the first or second MLD.~~

~~14. The first MLD according to claim 9, wherein one of a CCMP or a GCMP is used to cryptographically decapsulate the MPDU.~~

~~15. The first MLD according to claim 9, wherein the MPDU carries identification information of the first and second MLDs, wherein the circuitry cryptographically decapsulates the MPDU by setting the A2 field of the AAD and the Nonce to the MAC address that identifies the second MLD indicated in the MPDU, and by setting the A1 field of the AAD to the MAC address that identifies the first MLD indicated in the MPDU.~~

~~16. A method for retransmission of a MPDU in a multi-link communication, comprising:~~

~~setting up, at a first MLD configured to operate with a first plurality of affiliated STAs, a robust security network association (RSNA) with a second MLD that is configured to operate with a second plurality of affiliated STAs, wherein two or more links have been established between STAs of the first plurality of affiliated STAs and corresponding STAs of the second plurality of affiliated STAs;~~

~~constructing an Additional Authentication Data (AAD) and a Nonce, wherein the AAD includes an Address 1 (A1) field, an Address 2 (A2) field, an Address 3 (A3) and a Sequence Control (SC) field, and the Nonce includes an Address 2 (A2) field, wherein the SC field of the AAD is based on a SC field of the MPDU;~~

~~cryptographically encapsulating the MPDU using the AAD and Nonce to form an encapsulated MPDU;~~

~~transmitting the encapsulated MPDU from the first MLD to the second MLD on a first link as an initial transmission, and~~

~~retransmitting the encapsulated MPDU on a second link without reperforming the cryptographical encapsulation upon failure of the initial transmission.~~

9. A communication method for a transmitting multi-link device (MLD), the communication method comprising:

constructing an Additional Authentication Data (AAD) and a Nonce;

encapsulating a plaintext MAC protocol data unit (MPDU), the AAD and the Nonce to generate an encapsulated MPDU, wherein the AAD includes an Address 1 (A1) field to which a recipient MLD's medium access control (MAC) address is set, and an Address 2 (A2) field to which the transmitting MLD's MAC address is set, and wherein the Nonce includes an Address 2 (A2) field to which the transmitting MLD's MAC address is set; and

transmitting the encapsulated MPDU to the recipient MLD on a first link.

10. The communication method according to claim 9, wherein if the transmission of the encapsulated MPDU is unsuccessful, the communication method including:

retransmitting the MPDU on another link without encapsulating the MPDU with a new packet number (PN).

11. The communication method according to claim 9, wherein a common packet number (PN) is used for initial transmission on the first link and retransmission on another link.

12. The communication method according to claim 9, the transmitting MLD comprising a first plurality of affiliated STAs that are capable of establishing one or more links with a second plurality of affiliated STAs associated with the recipient MLD.

13. The communication method according to claim 9, wherein the settings of the A1 and A2 fields are indicated in one of a Counter Mode Cipher Block Chaining Message Authentication Code Protocol (CCMP) Header field or a Galois Counter Mode Protocol (GCMP) Header field of the encapsulated MPDU.

14. The communication method according to claim 9, wherein a common packet number (PN) is used for transmission and retransmission on a plurality of links.

15. The communication method according to claim 9, wherein one of a Counter Mode Cipher Block Chaining Message Authentication Code Protocol (CCMP) or a Galois Counter Mode Protocol (GCMP) is used to cryptographically protect the MPDU.

16. The communication method according to claim 9, comprising maintaining a single packet number (PN) space for a plurality of links.