[0005] MLDs thus seem to be useful to achieve multi-link WLAN sensing. However, there has been no related discussion in 802.11bf yet. In 802.11be, all EHT access points (APs) are affiliated with an AP MLD and there are no standalone EHT APs. On the other hand, in 802.11bf, all sensing related procedures assume signalling between two standalone peer STAs (e.g., between a non-Access Point (AP) STA and an AP). If either one or both of the peer STAs is affiliated with a multi-link device (MLD), it is not clear whether the sensing related procedures will work as defined in 802.11bf.

[0006] There is currently no detailed solution and procedure on how to make the 802.11bf WLAN sensing procedures work with STAs affiliated with MLDs. Thus, there is a need for communication apparatuses and methods to address the above mentioned issues by providing solutions and procedures of multi-link WLAN sensing as described in the present disclosure. Furthermore, other desirable features and characteristics will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and this background.

SUMMARY

[0007] One non-limiting and exemplary embodiment facilitates multi-link WLAN sensing procedures. In addition, the technical solutions provided in the present disclosure are not only applicable to a WLAN sensing procedure over multiple links using MLDs (i.e., multi-link WLAN sensing procedures), but also applicable to other WLAN applications such as Ranging for WLAN positioning (regulated by 802.11az and also known as fine time measurements) over multiple links (i.e. multi-link WLAN ranging procedures).

[0008] In an aspect, the techniques disclosed herein feature a first multi-link device (MLD) comprising a first plurality of affiliated stations (STAs), one of the first plurality of STAs is a first sensing initiator and comprises: a transmitter which

in operation, transmits on a first link a first Sensing Measurement Request frame to a first sensing responder which is one of a second plurality of STAs affiliated with a second MLD, the first Sensing Measurement Request frame including a first Measurement Setup ID; and a receiver configured to receive on the first link a Sensing Measurement Report frame from the sensing responder, the Sensing Measurement Report frame including the first Measurement Setup ID and a Remaining Feedback Segments field that indicates a number of remaining feedback segments corresponding to the first Sensing Measurement Request frame, the Sensing Measurement Report frame being to be used for location negotiation, movement detection or distance estimation of one or more target objects that are different from the first MLD and the second MLD.

[0008a] In another aspect, the techniques disclosed herein feature a method for a first multi-link device (MLD) comprising a first plurality of affiliated stations (STAs), wherein one of the first plurality of STAs is a first sensing initiator and comprises: transmitting, by the first sensing initiator, on a first link a first Sensing Measurement Request frame to a first sensing responder which is one of a second plurality of STAs affiliated with a second MLD, the first Sensing Measurement Request frame including a first Measurement Setup ID; and receiving, by the first sensing initiator, on the first link a Sensing Measurement Report frame from the sensing responder, the Sensing Measurement Report frame including the first Measurement Setup ID and a Remaining Feedback Segments field that indicates a number of remaining feedback segments corresponding to the first Sensing Measurement Request frame, the Sensing Measurement Report frame being to be used for location negotiation, movement detection or distance estimation of one or more target objects that are different from the first MLD and the second MLD.

[0009] It should be noted that general or specific embodiments may be implemented as a system, a device, a method, an integrated circuit, a computer program, a storage medium, or any selective combination thereof.

[0010] Additional benefits and advantages of the disclosed embodiments will become apparent from the specification and drawings. The benefits and/or advantages may be individually obtained by the various embodiments and features of the specification and drawings, which need not all be provided in order to obtain one or more of such benefits and/or advantages.

BRIEF DESCRIPTION OF THE FIGURES

[0011] In the following, exemplary embodiments are described in more detail with reference to the attached figures and drawings.

[0012] **FIG. 1** shows an exemplary WLAN sensing procedure 100 as defined in IEEE802.11bf. As described above, in 802.11bf, all sensing related procedures in the exemplary WLAN sensing procedure 100 assume signalling between two standalone peer STAs (e.g., a sensing initiator 102 and a sensing responder 104 as depicted in FIG. 1).

[0013] **FIG. 2** is a schematic illustration 200 which shows multi-link communications between two MLDs over multiple wireless links as defined in IEEE802.11be.

[0014] **FIG. 3** depicts a block diagram 300 of an exemplary communication apparatus 310 that can be implemented as a first MLD or a second MLD for multi-link WLAN sensing or ranging procedures in accordance with embodiments of the present disclosure based on practical requirements.

Claims

1. A first multi-link device (MLD) comprising a first plurality of affiliated stations (STAs), one of the first plurality of STAs is a first sensing initiator and comprises:

a transmitter configured to transmit on a first link a first Sensing Measurement Request frame to a first sensing responder which is one of a second plurality of STAs affiliated with a second MLD, the first Sensing Measurement Request frame including a first Measurement Setup ID; and

a receiver configured to receive on the first link a Sensing Measurement Report frame from the sensing responder, the Sensing Measurement Report frame including the first Measurement Setup ID and a Remaining Feedback Segments field that indicates a number of remaining feedback segments corresponding to the first Sensing Measurement Request frame, the Sensing Measurement Report frame being to be used for location negotiation, movement detection or distance estimation of one or more target objects that are different from the first MLD and the second MLD.

2. The first MLD of claim 1, wherein another one of the first plurality of STAs is a second sensing initiator and comprises:

a transmitter configured to transmit on a second link a second Sensing Measurement Request frame to a second sensing responder which is another one of the second plurality of STAs affiliated with the second MLD, the second Sensing Measurement Request frame including a second Measurement Setup ID

3. The first MLD of claim 2, wherein the Sensing Measurement Report frame is an aggregated Sensing Measurement Report frame that includes a plurality of Measurement Report fields and each of the plurality of Measurement Report fields includes a Measurement Setup ID and a Remaining Feedback Segments field that indicates a number of remaining feedback segments for a corresponding Sensing Measurement Request frame.

4. The first MLD of claim 3, wherein the first sensing initiator and the first sensing responder perform a sensing session setup or a sensing measurement setup before performing a Measurement Instance.

5. The first MLD of claim 1, wherein the first MLD is an Access Point (AP) MLD and the second MLD is a non-AP MLD and each of the first plurality of affiliated STAs is an AP, and each of the second plurality of affiliated STAs is a non-AP STA.

6. The first MLD of claim 3, wherein the Sensing Measurement Report frame is to be used for a location negotiation and ranging identifier (ID) assignment procedure.

7. The first MLD of claim 1, wherein the first MLD comprises a single interface to upper layer applications, wherein the upper layer applications configure the one or more STAs of the first plurality of affiliated STAs to perform the measurement operations with the one or more STAs of the second plurality of affiliated STAs comprised in the second MLD over one or more links.

8. The first MLD of claim 4, wherein a sensing measurement setup is identified with a same measurement setup identifier (ID) or different measurement setup IDs on one or more of the identified links, and for each of the one or more of the identified links.

9. The first MLD of claim 4, wherein a sensing measurement instance of a sensing measurement setup is identified with a same measurement instance identifier (ID) on one or more of the identified links and wherein for each of the one or more of the identified links:
a link ID of each of the one or more of the identified links together with the measurement instance ID is used to identify a sensing measurement instance specific to each of the one or more of the identified links.

10. The first MLD of claim 4, wherein the first MLD is configured to initiate a sensing measurement instance with the second MLD by transmitting a measurement PHY protocol data unit (PPDU) on a first link of the identified links and requesting a STA affiliated with the second MLD operating on the first link to perform sensing measurements on the measurement PPDU and another STA affiliated with the second MLD operating on a second link of the identified links to transmit a sensing measurement report on the second link,

wherein the sensing measurement report carries a result of the sensing measurement performed on the first link,

and wherein a STA affiliated with the first MLD operating on the second link is configured to receive the sensing measurement report.

11. A method for a first multi-link device (MLD) comprising a first plurality of affiliated stations (STAs), wherein one of the first plurality of STAs is a first sensing initiator and comprises:

transmitting, by the first sensing initiator, on a first link a first Sensing Measurement Request frame to a first sensing responder which is one of a second plurality of STAs affiliated with a second MLD, the first Sensing Measurement Request frame including a first Measurement Setup ID; and

receiving, by the first sensing initiator, on the first link a Sensing Measurement Report frame from the sensing responder, the Sensing Measurement Report frame including the first Measurement Setup ID and a Remaining Feedback Segments field that indicates a number of remaining feedback segments corresponding to the first Sensing Measurement Request frame, the Sensing Measurement Report frame being to be used for location negotiation, movement detection or distance estimation of one or more target objects that are different from the first MLD and the second MLD.

12. The method of claim 11, wherein another one of the first plurality of STAs is a second sensing initiator and further comprises:

transmitting, by the second sensing initiator, on a second link a second Sensing Measurement Request frame to a second sensing responder which is another one of the second plurality of STAs affiliated with the second MLD, the second Sensing Measurement Request frame including a second Measurement Setup ID.

13. The method of claim 12, wherein the Sensing Measurement Report frame is an aggregated Sensing Measurement Report frame that includes a plurality of Measurement Report fields and each of the plurality of Measurement Report fields includes a Measurement Setup ID and a Remaining Feedback Segments field that indicates a number of remaining feedback segments for a corresponding Sensing Measurement Request frame.

14. The method of claim 13, further comprising performing, by the first sensing initiator and the first sensing responder, a sensing session setup or a sensing measurement setup before performing a Measurement Instance.

15. The method of claim 11, wherein the first MLD is an Access Point (AP) MLD and the second MLD is a non-AP MLD and each of the first plurality of affiliated STAs is an AP, and each of the second plurality of affiliated STAs is a non-AP STA.

16. The method of claim 13, wherein the Sensing Measurement Report frame is to be used for a location negotiation and ranging identifier (ID) assignment procedure.

17. The method of claim 11, wherein the first MLD comprises a single interface to upper layer applications, wherein the upper layer applications configure the one or more STAs of the first plurality of affiliated STAs to perform the measurement operations with the one or more STAs of the second plurality of affiliated STAs comprised in the second MLD over one or more links.

18. The method of claim 14, wherein a sensing measurement setup is identified with a same measurement setup identifier (ID) or different measurement setup IDs on one or more of the identified links, and wherein for each of the one or more of the identified links.

19. The method of claim 14, wherein a sensing measurement instance of a sensing measurement setup is identified with a same measurement instance identifier (ID) on one or more of the identified links and wherein for each of the one or more of the identified links:

a link ID of each of the one or more of the identified links together with the measurement instance ID is used to identify a sensing measurement instance specific to each of the one or more of the identified links.

20. The method of claim 14, wherein the first MLD is configured to initiate a sensing measurement instance with the second MLD by transmitting a measurement PHY protocol data unit (PPDU) on a first link of the identified links and requesting a STA affiliated with the second MLD operating on the first link to perform sensing measurements on the measurement PPDU and another STA affiliated with the second MLD operating on a second link of the identified links to transmit a sensing measurement report on the second link,

wherein the sensing measurement report carries a result of the sensing measurement performed on the first link,

and wherein a STA affiliated with the first MLD operating on the second link is configured to receive the sensing measurement report.