such communication. Multi-channel aggregation over multiple links is a natural way to create multi-fold increase in communication data throughput.

[0004] In multi-link operations between an access point (AP) multi-link device (MLD) and non-AP MLDs, a traffic indication map (TIM) element is carried in Beacon frames, TIM frames etc., to indicate buffered traffic (BU) for associated non-AP STAs operating in power save (PS) node. In multi-link operations, in contrast to single link operation, just the BU indication in the TIM element does not provide additional information regarding the BUs such as the recommended link to retrieve the BU, or the TID associated with the BU etc. While methods can be used to signal additional information about buffered BUs such as link mapping, link-set indication with link recommendation and TID (traffic identifier) etc., in order for non-AP MLDs to correctly figure out their position in the Link/TID information set, additional bitmaps are required for each bit set to 1 in the TIM element regardless of the method used as will be explained later.

[0005] There is thus a need for a communication apparatus and a communication method for multi-link traffic indication map to solve the above-mentioned issues and reduce the overhead required for signaling additional information about buffered BUs in WLAN networks that contain MLDs. 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 of the disclosure.

SUMMARY

[0006] A non-limiting example facilitates providing communication apparatuses and communication methods for multi-link traffic indication map.

[0007] In one aspect, the present disclosure provides an access point (AP) of a plurality of APs affiliated with an AP multi-link device (MLD), each of the plurality of APs operating in a corresponding link of the AP MLD, the AP comprising: circuitry, which in operation, generates a frame comprising a traffic indication map (TIM) element and a presence bitmap, the element comprising a partial virtual bitmap (PVM) indicating presence of one or more buffered units for one of a non-AP STA or a non-AP MLD associated with the AP or the AP MLD, the presence bitmap indicating whether additional information relating to the one or more BUs is present in the frame for the one of the non-AP STA or the non-AP MLD; and a transmitter, which in operation, transmits the frame in a link.

[0008] In another aspect, the present disclosure provides a station (STA) of a plurality of STAs affiliated with a non-access-point (non-AP) multi-link device (MLD) associated with an AP MLD, each of the plurality of STAs operating in a corresponding link of the non-AP MLD, the STA comprising: a receiver, which in operation, receives a frame in a link, the frame comprising a traffic indication map (TIM) element and a presence bitmap, the element comprising a partial virtual bitmap (PVM) indicating presence of one or more buffered units for the non-AP MLD, the presence bitmap indicating whether additional information relating to the one or more BUs is present in the frame for the non-AP MLD; circuitry, which in operation, process the frame.

[0009] In another aspect, the present disclosure provides a communication method comprising: generating a frame comprising a traffic indication map (TIM) element and a presence bitmap, the element comprising a partial virtual bitmap (PVM) indicating presence of

one or more buffered units for one of a non-AP STA or a non-AP MLD associated with the AP or the AP MLD, the presence bitmap indicating whether additional information relating to the one or more BUs is present in the frame for the one of the non-AP STA or the non-AP MLD; and transmitting the frame in a link.

[0010] Additional benefits and advantages of the examples in the disclosure will become apparent from the specification and drawings. The benefits and/or advantages may be individually obtained by the various examples 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 DRAWINGS

[0011] The accompanying figures, where like reference numerals refer to identical or functionally similar elements throughout the separate views and which together with the detailed description below are incorporated in and form part of the specification, serve to illustrate various embodiments and to explain various principles and advantages in accordance with present embodiments.

[0012] Fig. 1 depicts a TIM element and Bitmap Control field of the TIM element.

[0013] Fig. 2 depicts a schematic diagram illustrating communications between an AP MLD and a non-AP MLD for multi-link power management and traffic indication.

[0014] Fig. 3 depicts a TIM bitmap and a set of Link mapping bitmap (LMBs).