multiple links is a natural way to create multi-fold increase in communication data throughput.

**[0004]** In order to enable such multi-link operations between an access point (AP) multi-link device (MLD) and a non-AP MLD, multi-link setup may be performed over one of the supported links to establish association for affiliated stations (STAs) in one or more links.

**[0005]** However, there has been no discussion so far concerning multi-link peer to peer communication between non-AP MLD STAs or between a non-AP MLD and a legacy STA.

**[0006]** There is thus a need for a communication apparatus and a communication method that can solve the above-mentioned issues. 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**

**[0007]** Non-limiting and exemplary ~~embodiment~~example**s** facilitate providing communication apparatuses and communication methods for multi-link peer-to-peer communication.

**[0008]** In a first ~~aspect~~example, the present disclosure provides a communication apparatus of a plurality of communication apparatuses affiliated with a first multi-link device (MLD), each of the plurality of communication apparatuses operating in a corresponding link of the first MLD, the communication apparatus comprising: circuitry, which in operation, generates a request frame, the request frame being one of a discovery request frame to discover a peer-to-peer communication capability of another communication apparatus, or a setup request frame to request setup of one or more direct links, the request frame carrying a multi-link (ML) indication identifying that the communication apparatus is affiliated with the first MLD; and a transmitter, which in operation, transmits the request frame in a link.

[0008a] In a first aspect, the present disclosure refers to a first non-Access Point (non-AP) multi-link device (MLD) including a plurality of affiliated stations (STAs), the non-AP MLD comprising a transmitter, which in operation, transmits a Tunnelled Direct Link Setup (TDLS) Setup Request frame via an Access Point (AP) to a second non-AP MLD, the TDLS Setup Request frame including a first TDLS Multi-Link element that contains a first MLD MAC address information and a receiver, which in operation, receives a TDLS Setup Response frame via the AP from the second non-AP MLD.

**[0009]** In a second ~~aspect~~example, the present disclosure provides an access point (AP) of a plurality of APs affiliated with an AP MLD, each of the plurality of APs operating in a corresponding link of the AP MLD, the AP comprising: a receiver, which in operation, receives in a link, from an associated communication apparatus affiliated with an MLD, a Data frame with a Destination Address (DA) field set to another associated communication apparatus that is not affiliated with an MLD; circuitry, which

in operation, sets a source address (SA) field of the Data frame as a MAC address of the associated communication apparatus ; and a transmitter, which in operation, transmits the Data frame to the other associated communication apparatus.

**[0010]** In a third ~~aspect~~example, the present disclosure provides a communication method comprising: generating a request frame, the request frame being one of a discovery request frame to discover a peer-to-peer communication capability of a communication

apparatus, or a setup request frame to request setup of one or more direct links, the request frame carrying an ML indication identifying that another communication apparatus transmitting the request frame is affiliated with an MLD; and transmitting the request frame in a link.

[0010a] In another aspect, the present disclosure refers to a communication method for a first non-Access Point (non-AP) multi-link device (MLD) including a plurality of affiliated stations (STAs), the communication method comprising: transmitting a Tunnelled Direct Link Setup (TDLS) Setup Request frame via an Access Point (AP) to a second non-AP MLD, the TDLS Setup Request frame including a first TDLS Multi-Link element that contains a first MLD MAC address information, and receiving a TDLS Setup Response frame via the AP from the second non-AP MLD.

**[0011]** Additional benefits and advantages of the disclosed ~~embodiment~~examples will become apparent from the specification and drawings. The benefits and/or advantages may be individually obtained by the various ~~embodiment~~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

**[0012]** 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.

**[0013]** Fig. 1 depicts a tunneled direct-link setup between two non-AP (access point) stations (STAs) associated with an AP in a basic service set (BSS).

**[0014]** Fig. 2A depicts a method for TDLS discovery performed using Tunneled Direct Link Setup (TDLS) Discovery frames.

**CLAIMS**

1. A ~~communication apparatus of a plurality of communication apparatuses affiliated with a~~ first non-Access Point (non-AP) multi-link device (MLD) including a plurality of affiliated stations (STAs), the non-AP MLD~~, each of the plurality of communication apparatuses operating in a corresponding link of the first MLD, the communication apparatus~~ comprising:

~~circuitry~~a transmitter, which in operation, ~~generates~~ transmits a Tunnelled Direct Link Setup (TDLS) Setup Request ~~request~~ frame via an Access Point (AP) to a second non-AP MLD, the TDLS Setup Request frame including a first TDLS Multi-Link element that contains a first MLD MAC address information~~, the request frame being one of a discovery request frame to discover a peer-to-peer communication capability of another communication apparatus, or a setup request frame to request setup of one or more direct links, the request frame carrying a multi-link (ML) indication identifying that the communication apparatus is affiliated with the first MLD~~; and

a ~~transmitter~~receiver, which in operation, ~~transmits the request frame in a~~receives a TDLS Setup Response frame via the AP from the second non-AP MLD ~~link~~.

2. The first non-AP MLD~~communication apparatus~~ according to claim 1, wherein the first ~~request frame is one of a Tunnelled Direct Link Setup (TDLS) Discovery Request frame, a TDLS Setup Request frame and an Access Network Query Protocol (ANQP) Request frame~~ TDLS Multi-Link element includes a Type subfield that is set to indicate TDLS and a Common Information field that carries the first MLD MAC address information.

3. The first non-AP MLD~~communication apparatus~~ according to claim 1, wherein

~~the ML indication is an ML element, the ML element carrying information about the first MLD and information of at least one other link supported by the first MLD~~prior to transmission of the TDLS Setup Request frame,

the transmitter, in operation, transmits a TDLS Discovery Request frame via the AP to the second non-AP MLD; and

the receiver, in operation, receives a TDLS Discovery Response frame a on a direct link from the second non-AP MLD.

4. The first non-AP MLD~~communication apparatus~~ according to claim ~~2~~3, wherein the ~~ML indication is included correspondingly in one of~~TDLS Discovery Request frame includes a Link Identifier element that contains a BSSID subfield ~~in the TDLS Discovery Request frame and a TDLS capability ANQP-element in the ANQP request frame~~.

5. The first non-AP MLD~~communication apparatus~~ according to claim ~~1~~3, ~~further comprising:~~wherein

~~a receiver, which in operation, receives, from the other communication apparatus, a~~the –TDLS Discovery ~~Response~~ Request frame ~~carrying~~ includes a second TDLS~~n~~ Multi-Link element~~, the ML element carrying information about a second MLD with which the other communication apparatus is affiliated~~that contains a second MLD MAC address information ~~and information of at least one other link supported by the second~~

~~MLD~~.

6. The first non-AP MLD~~communication apparatus~~ according to claim 1, ~~further comprising:~~wherein

~~a receiver, which in operation, receives, from the other communication apparatus, an ANQP response frame carrying an ML field, the ML field carrying information about a second MLD with which the other communication apparatus is affiliated and information of at least one other link supported by the second MLD~~the TDLS Setup Request frame carries a first TDLS Peer Key (TPK) handshake message;

the TDLS Setup Response frame carries a second TPK handshake message; and

the transmitter, in operation, transmits via the AP MLD a TDLS Setup Confirmation frame that carries a third TPK handshake message.

7. The first non-AP MLD~~communication apparatus~~ of claim ~~1~~6, wherein the TDLS Setup Request frame includes an RSNE, an Timeout Interval element and an FTE added to the first TDLS Multi-Link element~~the circuitry is further configured to generate at least one of a TDLS Setup Request frame and a TDLS Setup Confirm frame; the at least one of the TDLS Setup Request frame and the TDLS Setup Confirm frame carrying an ML element, the ML element carrying information about the first MLD and information of at least one other link supported by the first MLD; and~~

~~the transmitter further transmits the at least one of the TDLS Setup Request frame and the TDLS Setup Confirm frame to a second MLD with which the other communication apparatus is affiliated~~.

8. The first non-AP MLD~~communication apparatus~~ of claim ~~1~~3, wherein

~~further comprising:~~ the transmitter, in operation, transmits a request frame indicating a quiet time period for protecting a direct link communication ~~request frame indicating a quiet time period for protecting a direct link communication~~ on the direct link

~~a receiver, which in operation, receives, from the other communication apparatus, a TDLS Setup Response frame carrying an ML element, the ML element carrying information about a second MLD with which the other communication apparatus is affiliated and information of at least one other link supported by the second MLD~~.

~~9. The communication apparatus of claim 7, wherein, in response to an exchange of the TDLS Setup Request frame, the TDLS Setup Response frame and the TDLS Setup Confirm frame, the circuitry is further configured to:~~

~~set up one or more direct links between the first MLD and the second MLD.~~

~~10. The communication apparatus of claim 9, wherein the at least one of the TDLS Setup Request frame, the TDLS Setup Response frame and the TDLS Setup Confirm frame comprises TDLS PeerKey (TPK) handshake messages, and the circuitry is further configured to:~~

~~generate a TPK to encrypt one or more frames transmitted on the one or more direct link and/or decrypt one or more frames received on the one or more direct link.~~

~~11. The communication apparatus of claim 10, wherein each of the at least one of the TDLS Setup Request frame, the TDLS Setup Response frame and the TDLS Setup Confirm frame comprises a corresponding ML element, and the circuitry is further~~

~~configured to:~~

~~calculate a message integrity code of the each of the TDLS Setup Response frame and the TDLS Setup Confirm frame based on the corresponding ML element.~~

~~12. The communication apparatus of claim 9, wherein common multi-link features supported by the first MLD and the second MLD are available in the one or more direct links; the common multi-link features including multi-link block ack, cross link retransmission of frames, MLD MAC address based Additional Authentication Data and Nonce construction during an encapsulation or a decapsulation of frames under a Counter Mode with Cipher Block Chaining Message Authentication Code Protocol (CCMP) or a Galois/Counter Mode Protocol (GCMP).~~

~~13. The communication apparatus of claim 9, wherein the circuitry is further configured to generate a TDLS Channel Switch Request frame to switch from one to another one of the one or more direct links, the TDLS Channel Switch Request frame carrying an ML element, the ML element carrying information of the other one link of the one or more direct links; and~~

~~the transmitter further transmits the TDLS Channel Switch Request frame to the second MLD.~~

~~14. An access point (AP) of a plurality of APs affiliated with an AP MLD, each of the plurality of APs operating in a corresponding link of the AP MLD, the AP comprising:~~

~~a receiver, which in operation, receives in a link, from an associated communication apparatus affiliated with an MLD, a Data frame with a Destination~~

~~Address (DA) field set to another associated communication apparatus that is not affiliated with an MLD;~~

~~circuitry, which in operation, sets a source address (SA) field of the Data frame as a MAC address of the associated communication apparatus; and~~

~~a transmitter, which in operation, transmits the Data frame to the other associated communication apparatus.~~

~~15~~9. A communication method for a first non-Access Point (non-AP) multi-link device (MLD) including a plurality of affiliated stations (STAs), the communication method comprising:

~~generating a request frame, the request frame being one of a discovery request frame to discover a peer-to-peer communication capability of a communication apparatus, or a setup request frame to request setup of one or more direct links, the request frame carrying an ML indication identifying that another communication apparatus transmitting the request frame is affiliated with an MLD; and~~

transmitting a Tunnelled Direct Link Setup (TDLS) Setup Request frame via an Access Point (AP) to a second non-AP MLD, the TDLS Setup Request frame including a first TDLS Multi-Link element that contains a first MLD MAC address information; and

receiving a TDLS Setup Response frame via the AP from the second non-AP MLD ~~the request frame in a link~~.

10. The communication method according to claim 9, wherein the first TDLS Multi-Link element includes a Type subfield that is set to indicate TDLS and a Common Information field that carries the first MLD MAC address information.

11. The communication method according to claim 9, wherein

prior to transmission of the TDLS Setup Request frame, the communication method comprising:

transmitting a TDLS Discovery Request frame via the AP to the second non-AP MLD; and

receiving a TDLS Discovery Response frame a on a direct link from the second non-AP MLD.

12. The communication method according to claim 11, wherein the TDLS Discovery Request frame includes a Link Identifier element that contains a BSSID subfield.

13. The communication method according to claim 11, wherein

the TDLS Discovery Request frame includes a second TDLS Multi-Link element that contains a second MLD MAC address information.

14. The communication method according to claim 9, wherein

the TDLS Setup Request frame carries a first TDLS Peer Key (TPK) handshake message;

the TDLS Setup Response frame carries a second TPK handshake message; and

the communication method comprising:

transmitting via the AP MLD a TDLS Setup Confirmation frame that carries a third TPK handshake message.

15. The communication method of claim 14, wherein the TDLS Setup Request frame includes an RSNE, a Timeout Interval element and an FTE added to the first TDLS Multi-Link element.

16. The communication method of claim 11, comprising

transmitting a request frame indicating a quiet time period for protecting a direct link communication~~request frame indicating a quiet time period for protecting a direct link communication~~ Quiet Time Period (QTP) Request frame to the AP MLD for setting up a QTP on the direct link.