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Xue et al.

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(45) **Date of Patent: Apr. 9, 2019**

(54) **BINDING REGISTRATION METHOD, DATA FORWARDING METHOD, RELATED DEVICE, AND NETWORK SYSTEM**

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(73) Assignees: **Huawei Technologies Co., Ltd.**, Shenzhen (CN); **University of Science and Technology of China**, Hefei (CN)

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H04W 8/06 (2009.01)
H04W 60/04 (2009.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04W 60/04*** (2013.01); ***H04L 12/4633*** (2013.01); ***H04L 61/2038*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H04W 60/04; H04W 8/06; H04W 8/082; H04W 8/10; H04W 40/00; H04L 12/4633; H04L 61/2038; H04L 61/305
See application file for complete search history.

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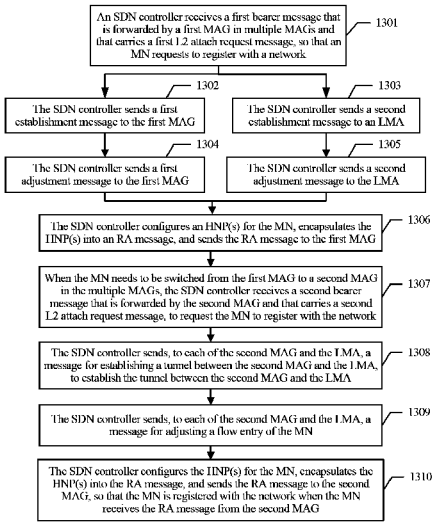
Primary Examiner — Kevin D Mew
(74) *Attorney, Agent, or Firm* — Leydig, Voit & Mayer, Ltd.

(57) **ABSTRACT**

A binding registration method includes: an SDN controller receiving a first bearer message that is forwarded by a first MAG in multiple MAGs and that carries a first L2 attach request message; sending, to each of the first MAG and an LMA, a message for establishing a tunnel between the first MAG and the LMA; sending, to each of the first MAG and the LMA, a message for adjusting a flow entry of an MN; configuring an HNP(s) for the MN, and encapsulating the HNP(s) into an RA message; and sending the RA message to the first MAG.

20 Claims, 10 Drawing Sheets



(51) **Int. Cl.**

H04L 12/46	(2006.01)
H04L 29/12	(2006.01)
H04W 8/10	(2009.01)
H04W 8/08	(2009.01)
H04W 40/00	(2009.01)

(52) **U.S. Cl.**

CPC ***H04W 8/06*** (2013.01); ***H04W 8/082*** (2013.01); ***H04W 8/10*** (2013.01); ***H04W 40/00*** (2013.01); *H04L 61/305* (2013.01)

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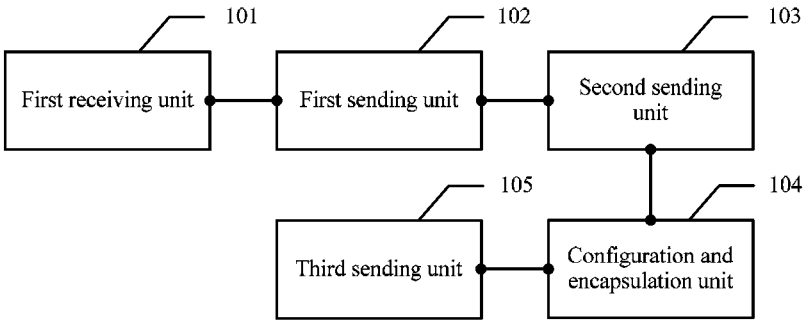
101
102
103
First receiving unit
First sending unit
Second sending unit
105
104
Third sending unit
Configuration and encapsulation unit

FIG. 1

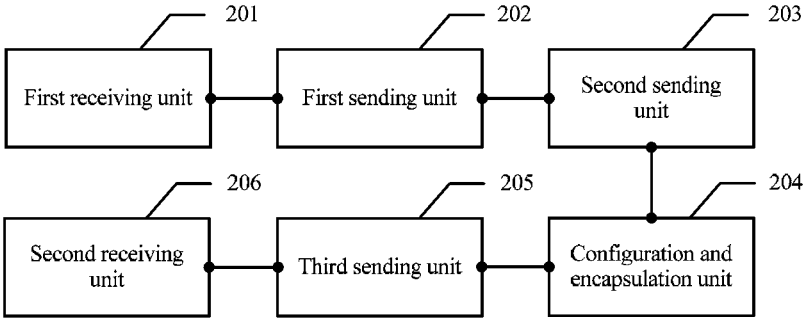
201
202
203
First receiving unit
First sending unit
Second sending unit
206
205
204
Second receiving unit
Third sending unit
Configuration and encapsulation unit

FIG. 2

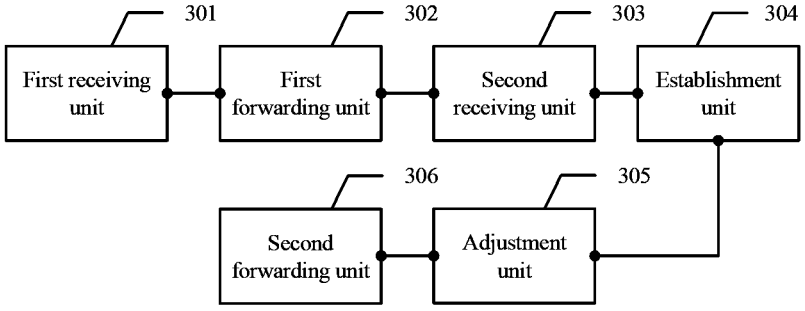
301
First receiving unit
302
First forwarding unit
303
Second receiving unit
304
Establishment unit
306
Second forwarding unit
305
Adjustment unit

FIG. 3

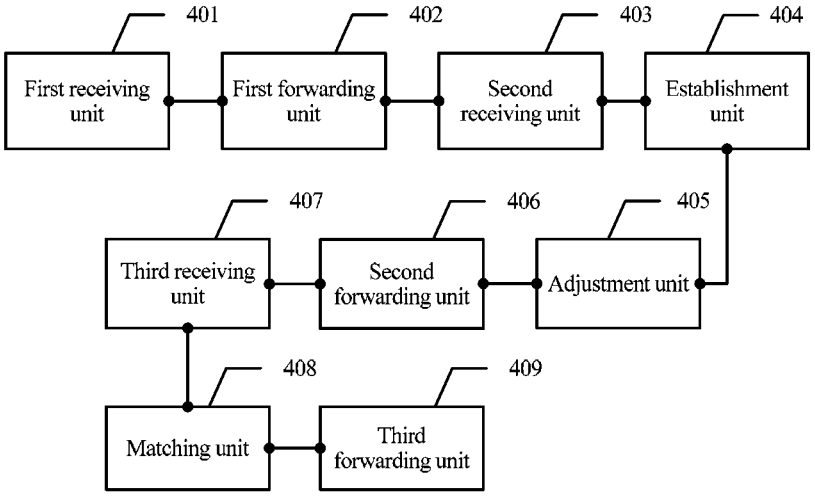
401
First receiving unit
402
First forwarding unit
403
Second receiving unit
404
Establishment unit
407
Third receiving unit
406
Second forwarding unit
405
Adjustment unit
408
Matching unit
409
Third forwarding unit

FIG. 4

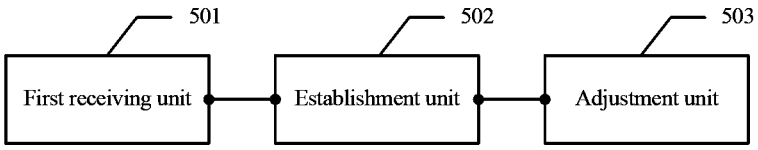

FIG. 5

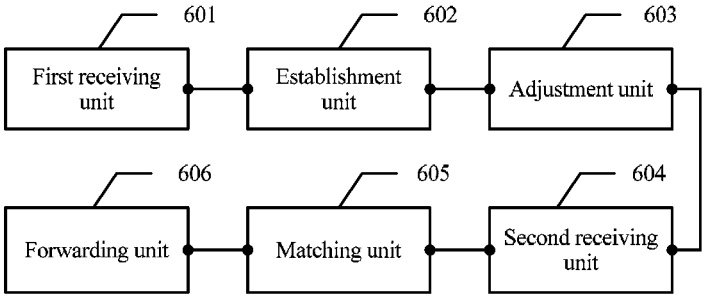

FIG. 6

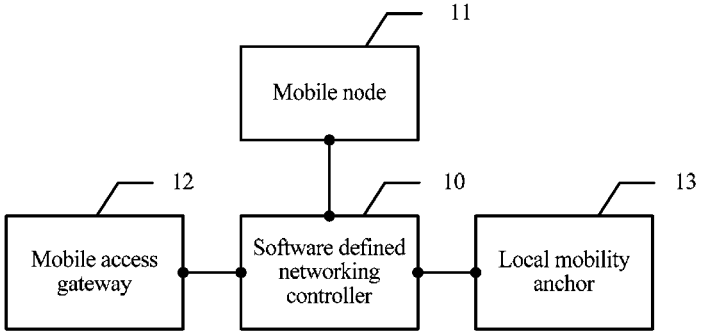

FIG. 7

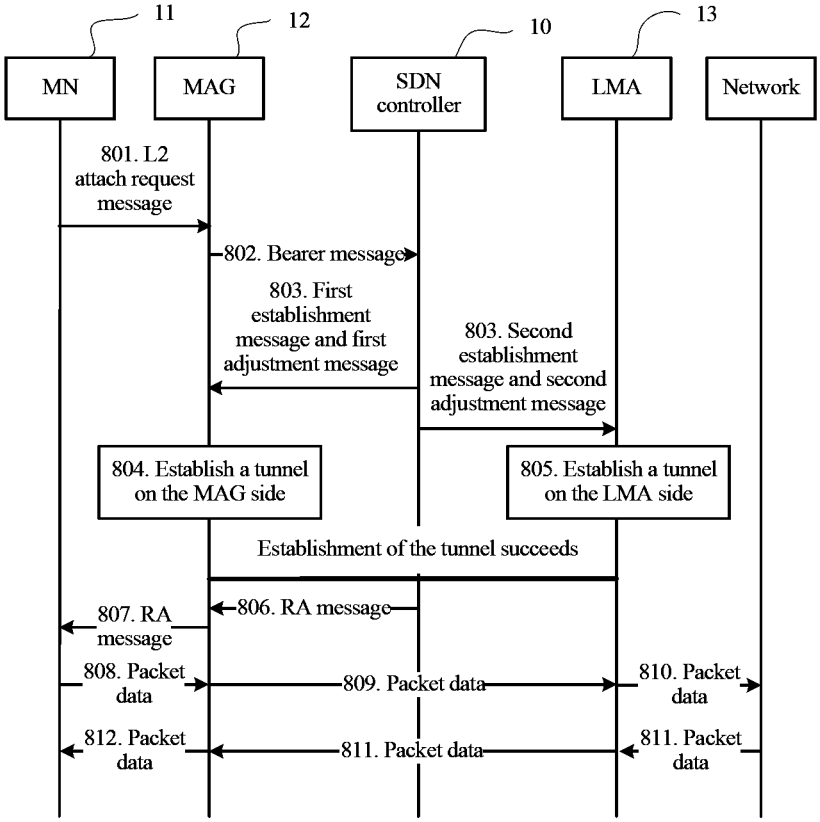
11
12
10
13
MN
MAG
SDN controller
LMA
Network
801. L2 attach request message
802. Bearer message
803. First establishment message and first adjustment message
803. Second establishment message and second adjustment message
804. Establish a tunnel on the MAG side
805. Establish a tunnel on the LMA side
Establishment of the tunnel succeeds
806. RA message
807. RA message
808. Packet data
809. Packet data
810. Packet data
811. Packet data
812. Packet data

FIG. 8

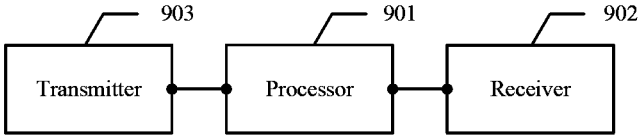
903
901
902
Transmitter
Processor
Receiver

FIG. 9

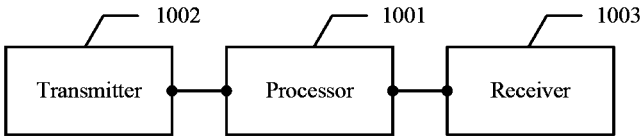

FIG. 10

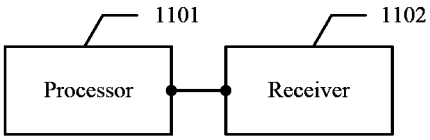

FIG. 11

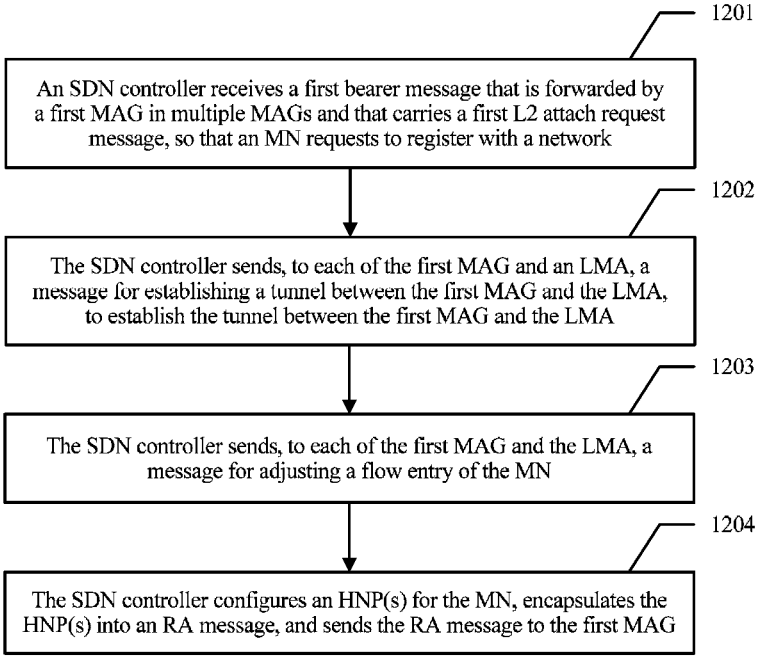

FIG. 12

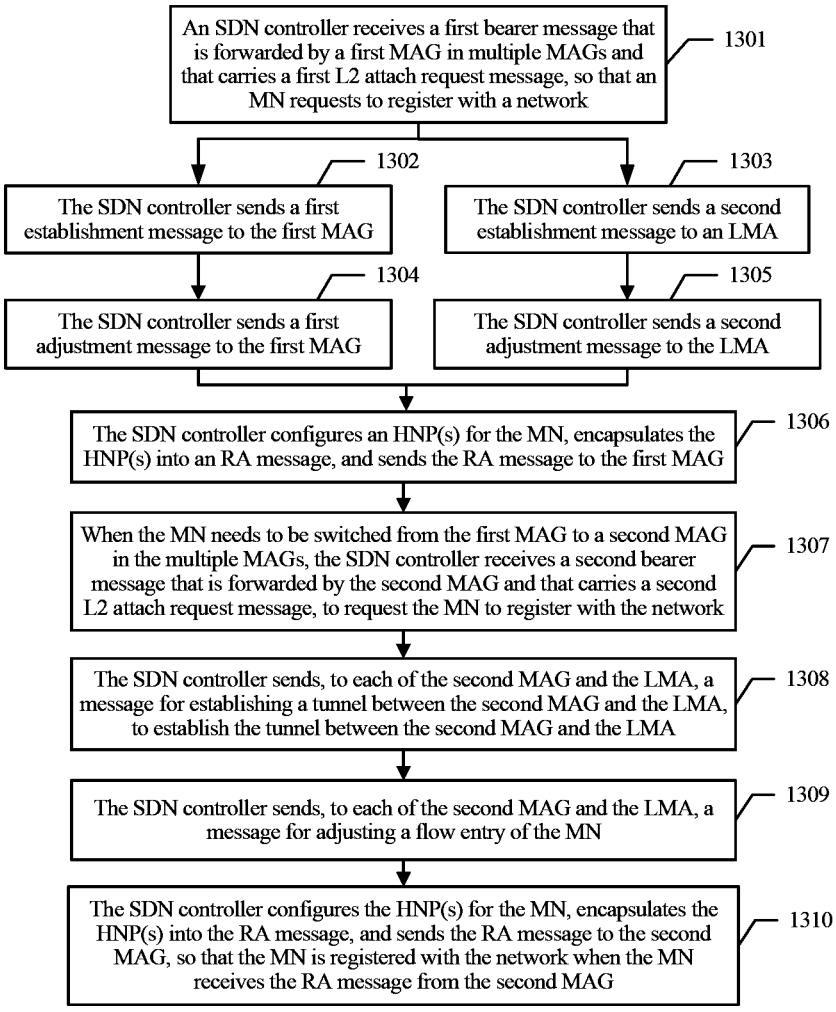
An SDN controller receives a first bearer message that is forwarded by a first MAG in multiple MAGs and that carries a first L2 attach request message, so that an MN requests to register with a network
1301
1302
The SDN controller sends a first establishment message to the first MAG
1303
The SDN controller sends a second establishment message to an LMA
1304
The SDN controller sends a first adjustment message to the first MAG
1305
The SDN controller sends a second adjustment message to the LMA
The SDN controller configures an HNP(s) for the MN, encapsulates the HNP(s) into an RA message, and sends the RA message to the first MAG
1306
When the MN needs to be switched from the first MAG to a second MAG in the multiple MAGs, the SDN controller receives a second bearer message that is forwarded by the second MAG and that carries a second L2 attach request message, to request the MN to register with the network
1307
The SDN controller sends, to each of the second MAG and the LMA, a message for establishing a tunnel between the second MAG and the LMA, to establish the tunnel between the second MAG and the LMA
1308
The SDN controller sends, to each of the second MAG and the LMA, a message for adjusting a flow entry of the MN
1309
The SDN controller configures the HNP(s) for the MN, encapsulates the HNP(s) into the RA message, and sends the RA message to the second MAG, so that the MN is registered with the network when the MN receives the RA message from the second MAG
1310

FIG. 13

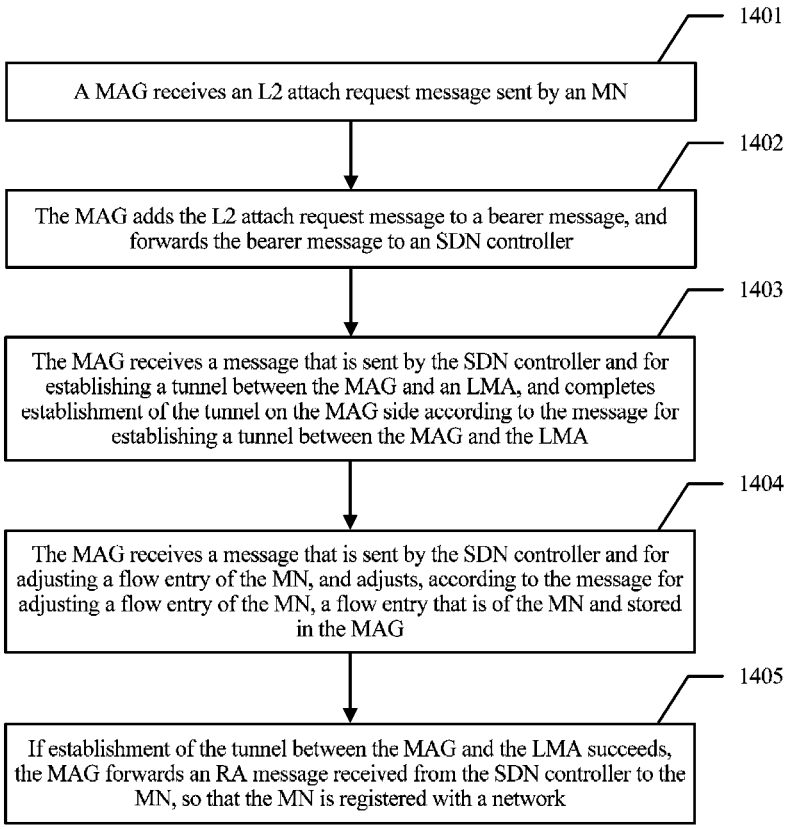
1401
A MAG receives an L2 attach request message sent by an MN
1402
The MAG adds the L2 attach request message to a bearer message, and forwards the bearer message to an SDN controller
1403
The MAG receives a message that is sent by the SDN controller and for establishing a tunnel between the MAG and an LMA, and completes establishment of the tunnel on the MAG side according to the message for establishing a tunnel between the MAG and the LMA
1404
The MAG receives a message that is sent by the SDN controller and for adjusting a flow entry of the MN, and adjusts, according to the message for adjusting a flow entry of the MN, a flow entry that is of the MN and stored in the MAG
1405
If establishment of the tunnel between the MAG and the LMA succeeds, the MAG forwards an RA message received from the SDN controller to the MN, so that the MN is registered with a network

FIG. 14

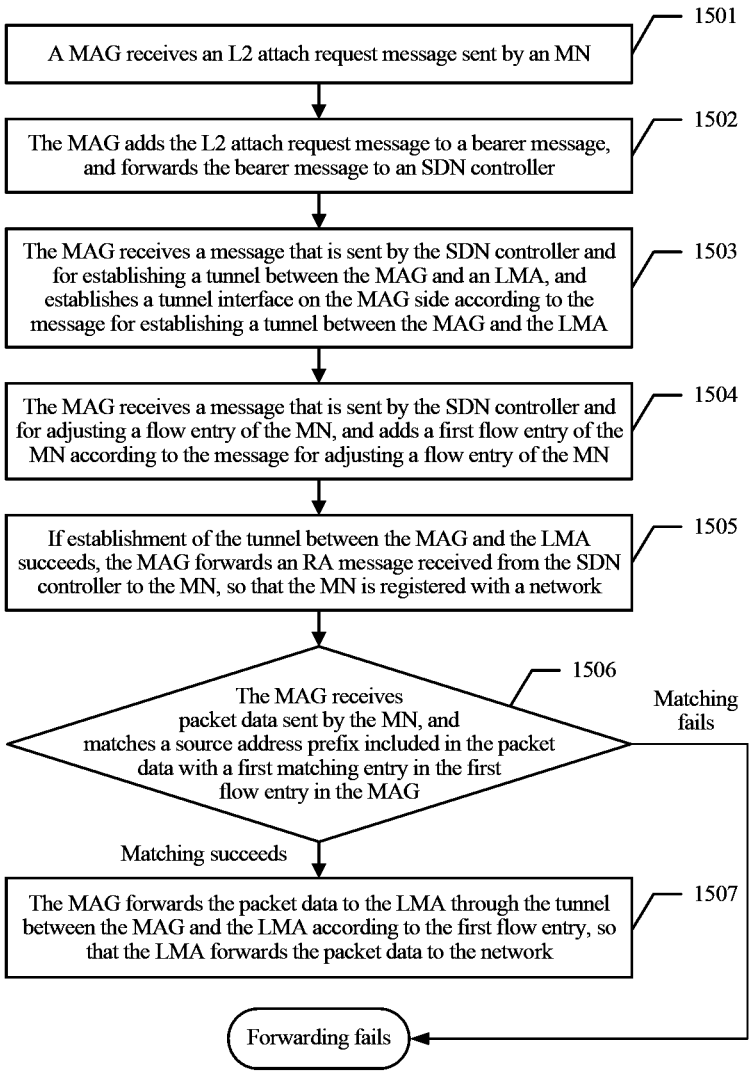
1501
A MAG receives an L2 attach request message sent by an MN
1502
The MAG adds the L2 attach request message to a bearer message, and forwards the bearer message to an SDN controller
1503
The MAG receives a message that is sent by the SDN controller and for establishing a tunnel between the MAG and an LMA, and establishes a tunnel interface on the MAG side according to the message for establishing a tunnel between the MAG and the LMA
1504
The MAG receives a message that is sent by the SDN controller and for adjusting a flow entry of the MN, and adds a first flow entry of the MN according to the message for adjusting a flow entry of the MN
1505
If establishment of the tunnel between the MAG and the LMA succeeds, the MAG forwards an RA message received from the SDN controller to the MN, so that the MN is registered with a network
1506
The MAG receives packet data sent by the MN, and matches a source address prefix included in the packet data with a first matching entry in the first flow entry in the MAG
Matching fails
Matching succeeds
1507
The MAG forwards the packet data to the LMA through the tunnel between the MAG and the LMA according to the first flow entry, so that the LMA forwards the packet data to the network
Forwarding fails

FIG. 15

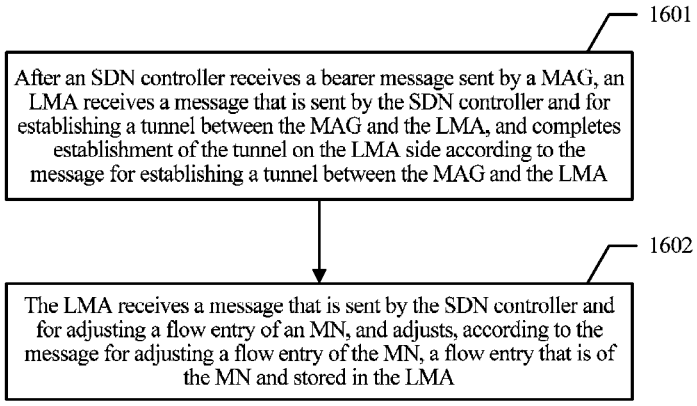
1601
After an SDN controller receives a bearer message sent by a MAG, an LMA receives a message that is sent by the SDN controller and for establishing a tunnel between the MAG and the LMA, and completes establishment of the tunnel on the LMA side according to the message for establishing a tunnel between the MAG and the LMA
1602
The LMA receives a message that is sent by the SDN controller and for adjusting a flow entry of an MN, and adjusts, according to the message for adjusting a flow entry of the MN, a flow entry that is of the MN and stored in the LMA

FIG. 16

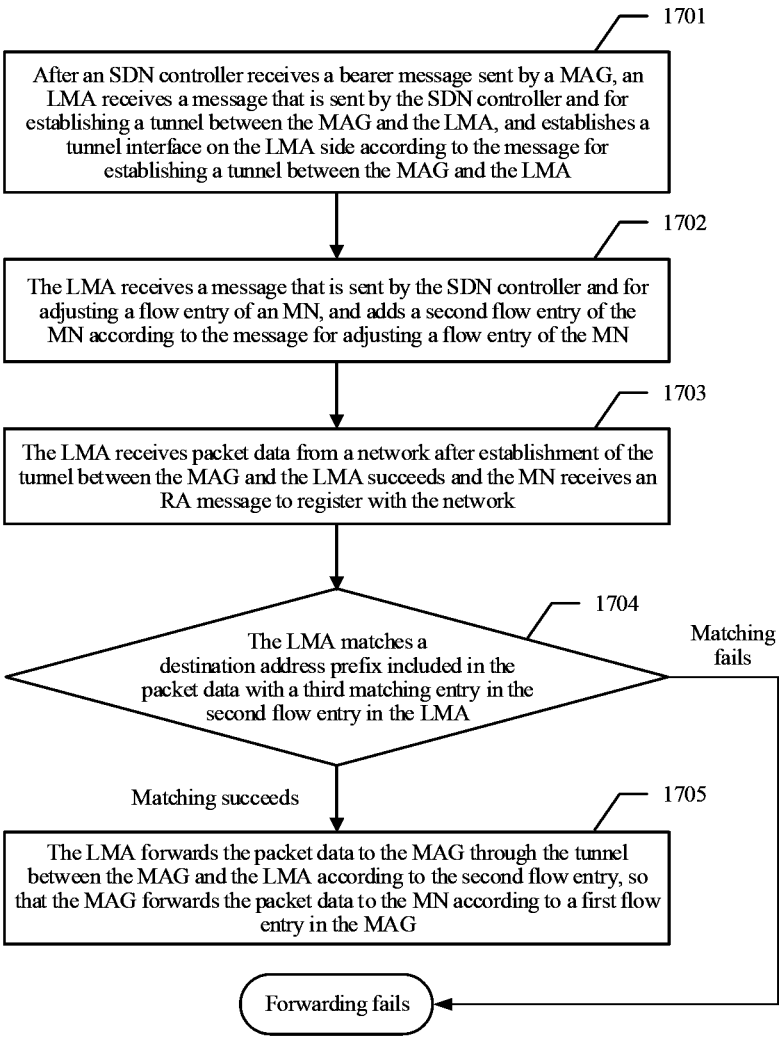
1701
After an SDN controller receives a bearer message sent by a MAG, an LMA receives a message that is sent by the SDN controller and for establishing a tunnel between the MAG and the LMA, and establishes a tunnel interface on the LMA side according to the message for establishing a tunnel between the MAG and the LMA
1702
The LMA receives a message that is sent by the SDN controller and for adjusting a flow entry of an MN, and adds a second flow entry of the MN according to the message for adjusting a flow entry of the MN
1703
The LMA receives packet data from a network after establishment of the tunnel between the MAG and the LMA succeeds and the MN receives an RA message to register with the network
1704
The LMA matches a destination address prefix included in the packet data with a third matching entry in the second flow entry in the LMA
Matching fails
Matching succeeds
1705
The LMA forwards the packet data to the MAG through the tunnel between the MAG and the LMA according to the second flow entry, so that the MAG forwards the packet data to the MN according to a first flow entry in the MAG
Forwarding fails

FIG. 17

BINDING REGISTRATION METHOD, DATA FORWARDING METHOD, RELATED DEVICE, AND NETWORK SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of International Application No. PCT/CN2014/078310, filed on May 23, 2014, the disclosure of which is hereby incorporated by reference in its entirety.

STATEMENT OF JOINT RESEARCH AGREEMENT

The subject matter and the claimed invention were made by or on the behalf of University of Science and Technology of China, of No. 96, JinZhai Road, Baohe District, Hefei City, Anhui Province, P.R. China and Huawei Technologies Co., Ltd., of Shenzhen, Guangdong Province, P.R. China, under a joint research agreement titled "Research and Development of Next Generation Video Coding Standards and Technologies". The joint research agreement was in effect on or before the claimed invention was made, and that the claimed invention was made as a result of activities undertaken within the scope of the joint research agreement.

TECHNICAL FIELD

The present invention relates to the communications field, and in particular, to a binding registration method, a data forwarding method, a related device, and a network system.

BACKGROUND

The Proxy Mobile IPv6 protocol provides network side-based mobility management support for a mobile node (MN), and does not require participation of the mobile node in signaling interworking related to mobility management, so that a user-side protocol stack does not need to be complexly extended. In the Proxy Mobile IPv6 protocol, a network layer is extended by adding two core functional entities, which are a local mobility anchor (LMA) and a mobile access gateway (MAG). The LMA is responsible for maintaining a reachable status of the mobile node and allocating a home network prefix of the mobile node. The MAG is located on a link to which the mobile node is anchored, and performs mobility management in place of the mobile node and completes binding registration with the LMA in place of the mobile node.

In an existing PMIPv6 mobility management solution, when the mobile node performs initial access, the mobile node first requests to be attached to a network. The MAG to which the mobile node is currently anchored acquires a mobile node identification (MN-ID) of the mobile node, and then the MAG sends the LMA a Proxy Binding Update (PBU) message that carries the MN-ID. After receiving the PBU message, the LMA returns, to the MAG, a Proxy Binding Acknowledgement (PBA) that carries a home network prefix (HNP) of the mobile node, and then the LMA negotiates with the MAG to establish a bidirectional tunnel. Subsequently, the MAG announces, to the mobile node on an access link, a router advertisement (RA) message that carries the HNP(s) of the mobile node, to complete a binding registration process.

In the existing PMIPv6 mobility management solution, because the network element devices LMA and MAG perform plenty of signaling negotiation and interworking, control functions are very complex. Especially when the mobile node moves frequently, the LMA and different MAGs need to perform more frequent and complex signaling interworking. In addition, the network element devices LMA and MAG are applicable only to the Proxy Mobile IPv6 protocol, and if the protocol is changed, the network element devices accordingly need to be changed, causing a huge waste in network construction.

SUMMARY

Embodiments of the present invention provide a binding registration method, a data forwarding method, a related device, and a network system, which resolves a problem in the Proxy Mobile IPv6 protocol that because a network element device performs plenty of signaling negotiation and interworking, a control function is complex, and resolves a problem of a waste in network construction resulted from a change of the network element device that is caused by a protocol change.

A first aspect of the embodiments of the present invention provides a software defined networking SDN controller, including:

a first receiving unit, configured to receive a first bearer message that is forwarded by a first MAG in multiple mobile access gateways MAGs and that carries a first data link layer L2 attach request message, so that a mobile node requests to register with a network, where the first L2 attach request message is sent by the mobile node to the first MAG to request to access the first MAG, and the first L2 attach request message includes an ID of the mobile node;

a first sending unit, configured to send, to each of the first MAG and an LMA, a message for establishing a tunnel between the first MAG and the local mobility anchor LMA, to establish the tunnel between the first MAG and the LMA;

a second sending unit, configured to send, to each of the first MAG and the LMA, a message for adjusting a flow entry of the mobile node;

a configuration and encapsulation unit, configured to: when establishment of the tunnel between the first MAG and the LMA succeeds, configure HNP(s) for the mobile node, and encapsulate the HNP(s) into a router advertisement message; and

a third sending unit, configured to send the router advertisement message to the first MAG, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the first MAG

With reference to the first aspect of the embodiments of the present invention, in a first implementation manner of the first aspect, the first sending unit is configured to send a first establishment message to the first MAG, where the first establishment message is used to instruct the first MAG to establish a tunnel interface on the first MAG side, and the first establishment message includes configuration information for establishing the tunnel interface on the first MAG side;

the first sending unit is further configured to send a second establishment message to the LMA, where the second establishment message is used to instruct the LMA to establish a tunnel interface on the LMA side, and the second establishment message includes configuration information for establishing the tunnel interface on the LMA side;

the second sending unit is configured to send a first adjustment message to the first MAG, where the first adjustment message is used to instruct the first MAG to add a first flow entry of the mobile node; and

the second sending unit is further configured to send a second adjustment message to the LMA, where the second adjustment message is used to instruct the LMA to add a second flow entry of the mobile node.

With reference to the first implementation manner of the first aspect of the embodiments of the present invention, in a second implementation manner of the first aspect, the first flow entry is used to instruct the first MAG to forward data according to content of the first flow entry; and

the second flow entry is used to instruct the LMA to forward data according to content of the second flow entry.

With reference to the second implementation manner of the first aspect of the embodiments of the present invention, in a third implementation manner of the first aspect, the content of the first flow entry includes: a first matching entry: a source address prefix is the HNP(s) of the mobile node; an operation corresponding to the first matching entry: forwarding through a first MAG-LMA tunnel interface; a second matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the second matching entry: forwarding to a mobile node interface link; and

the content of the second flow entry includes: a third matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the third matching entry: forwarding through an LMA-first MAG tunnel interface.

With reference to the first aspect of the embodiments of the present invention, or the first implementation manner of the first aspect, or the second implementation manner of the first aspect, or the third implementation manner of the first aspect, in a fourth implementation manner of the first aspect, the SDN controller further includes:

a second receiving unit, configured to: when the mobile node needs to be switched from the first MAG to a second MAG in the multiple MAGs, receive a second bearer message that is forwarded by the second MAG and that carries a second L2 attach request message, so that the mobile node requests to register with the network, where the second L2 attach request message is sent by the mobile node to the second MAG to request to access the second MAG, and the second L2 attach request message includes the ID of the mobile node; where

the first sending unit is further configured to send, to each of the second MAG and the LMA, a message for establishing a tunnel between the second MAG and the LMA, to establish the tunnel between the second MAG and the LMA;

the second sending unit is further configured to send, to each of the second MAG and the LMA, the message for adjusting a flow entry of the mobile node;

the configuration and encapsulation unit is further configured to: when establishment of the tunnel between the second MAG and the LMA succeeds, configure the HNP(s) for the mobile node, and encapsulate the HNP (s) into the router advertisement message; and

the third sending unit is further configured to send the router advertisement message to the second MAG when establishment of the tunnel between the second MAG and the LMA succeeds, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the second MAG, where the router advertisement message includes the HNP(s) configured by the SDN controller for the mobile node.

With reference to the fourth implementation manner of the first aspect of the embodiments of the present invention, in a fifth implementation manner of the first aspect of the embodiments of the present invention, the first sending unit is configured to send a third establishment message to the second MAG, where the third establishment message is used to instruct the second MAG to establish a tunnel interface on the second MAG side, and the third establishment message includes configuration information for establishing the tunnel interface on the second MAG side;

the first sending unit is further configured to send a fourth establishment message to the LMA, where the fourth establishment message is used to instruct the LMA to establish a tunnel interface on the LMA side, and the fourth establishment message includes configuration information for establishing the tunnel interface on the LMA side;

the second sending unit is configured to send a third adjustment message to the second MAG, where the third adjustment message is used to instruct the second MAG to add a third flow entry of the mobile node; and

the second sending unit is further configured to send a fourth adjustment message to the LMA, where the fourth adjustment message is used to instruct the LMA to add a fourth flow entry of the mobile node.

With reference to the fifth implementation manner of the first aspect of the embodiments of the present invention, in a sixth implementation manner of the first aspect of the embodiments of the present invention, the third flow entry is used to instruct the second MAG to forward data according to content of the third flow entry; and

the fourth flow entry is used to instruct the LMA to forward data according to content of the fourth flow entry.

With reference to the sixth implementation manner of the first aspect of the embodiments of the present invention, in a seventh implementation manner of the first aspect of the embodiments of the present invention, the content of the third flow entry includes: a fourth matching entry: a source address prefix is the HNP(s) of the mobile node; an operation corresponding to the fourth matching entry: forwarding through a second MAG-LMA tunnel interface; a fifth matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the fifth matching entry: forwarding to the mobile node interface link; and

the content of the fourth flow entry includes: a sixth matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the sixth matching entry: forwarding through an LMA-second MAG tunnel interface.

A second aspect of the embodiments of the present invention provides a mobile access gateway MAG, including:

a first receiving unit, configured to receive a data link layer L2 attach request message sent by a mobile node, where the L2 attach request message includes an ID of the mobile node;

a first forwarding unit, configured to: add the L2 attach request message to a bearer message, and forward the bearer message to a software defined networking SDN controller;

a second receiving unit, configured to receive a message that is sent by the SDN controller and for establishing a tunnel between the MAG and a local mobility anchor LMA;

an establishment unit, configured to complete establishment of the tunnel on the MAG side according to the message for establishing a tunnel between the MAG and the LMA; where

the second receiving unit is further configured to receive a message that is sent by the SDN controller and for adjusting a flow entry of the mobile node;

an adjustment unit, configured to adjust, according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the MAG; and

a second forwarding unit, configured to: when establishment of the tunnel between the MAG and the LMA succeeds, forward a router advertisement message received from the SDN controller to the mobile node, so that the mobile node is registered with a network, where the router advertisement message includes HNP(s) configured by the SDN controller for the mobile node.

With reference to the second aspect of the embodiments of the present invention, in a first implementation manner of the second aspect of the embodiments of the present invention, the second receiving unit is further configured to receive an establishment message and an adjustment message that are sent by the SDN controller;

the establishment unit is further configured to establish a tunnel interface on the MAG side according to the establishment message; and

the adjustment unit is configured to add a first flow entry of the mobile node according to the adjustment message.

With reference to the first implementation manner of the second aspect of the embodiments of the present invention, in a second implementation manner of the second aspect of the embodiments of the present invention, content of the first flow entry includes: a first matching entry: a source address prefix is the HNP(s) of the mobile node; an operation corresponding to the first matching entry: forwarding through a MAG-LMA tunnel interface; a second matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the second matching entry: forwarding to an mobile node interface link.

With reference to the first implementation manner of the second aspect of the embodiments of the present invention, or the second implementation manner of the second aspect, in a third implementation manner of the second aspect of the embodiments of the present invention, the MAG further includes:

a third receiving unit, configured to: after the mobile node is registered with the network, receive packet data sent by the mobile node;

a matching unit, configured to match a source address prefix included in the packet data with the first matching entry in the first flow entry in the MAG; and

a third forwarding unit, configured to: when the matching unit successfully performs matching, forward the packet data to the LMA through the tunnel between the MAG and the LMA according to the first flow entry, so that the LMA forwards the packet data to the network.

A third aspect of the embodiments of the present invention provides a local mobility anchor LMA, including:

a first receiving unit, configured to: after a software defined networking SDN controller receives a bearer message sent by a mobile access gateway MAG, receive a message that is sent by the SDN controller and for establishing a tunnel between the MAG and the LMA, where the bearer message carries a data link layer L2 attach request message, the L2 attach request message is sent by a mobile node to the MAG to request to access the MAG, and the L2 attach request message includes an ID of the mobile node;

an establishment unit, configured to complete establishment of the tunnel on the LMA side according to the message for establishing a tunnel between the MAG and the LMA; where

the first receiving unit is further configured to receive a message that is sent by the SDN controller and for adjusting a flow entry of the mobile node; and

an adjustment unit, configured to adjust, according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the LMA.

With reference to the third aspect of the embodiments of the present invention, in a first implementation manner of the third aspect of the embodiments of the present invention, the first receiving unit is further configured to receive an establishment message and an adjustment message that are sent by the SDN controller; and

the establishment unit is further configured to establish a tunnel interface on the LMA side according to the establishment message; and the adjustment unit is further configured to add a second flow entry of the mobile node according to the adjustment message.

With reference to the first implementation manner of the third aspect of the embodiments of the present invention, in a second implementation manner of the third aspect of the embodiments of the present invention, content of the second flow entry includes: a third matching entry: a destination address prefix is an HNP(s) of the mobile node; and an operation corresponding to the third matching entry: forwarding through an LMA-MAG tunnel interface.

With reference to the first implementation manner of the third aspect of the embodiments of the present invention, or the second implementation manner of the third aspect, in a third implementation manner of the third aspect of the embodiments of the present invention, the LMA further includes:

a second receiving unit, configured to receive packet data from a network after establishment of the tunnel between the MAG and the LMA succeeds and the mobile node receives a router advertisement message to register with the network;

a matching unit, configured to match a destination address prefix included in the packet data with the third matching entry in the second flow entry in the LMA; and

a forwarding unit, configured to: when the matching unit successfully performs matching, forward the packet data to the MAG through the tunnel between the MAG and the LMA according to the second flow entry, so that the MAG forwards the packet data to the mobile node according to the first flow entry in the MAG

With reference to the third implementation manner of the third aspect of the embodiments of the present invention, in a fourth implementation manner of the third aspect of the embodiments of the present invention, content of the first flow entry includes: a first matching entry: a source address prefix is the HNP(s) of the mobile node; an operation corresponding to the first matching entry: forwarding through a MAG-LMA tunnel interface; a second matching entry: a destination address prefix is the HNP(s) of the

mobile node; and an operation corresponding to the second matching entry: forwarding to a mobile node interface link.

A fourth aspect of the embodiments of the present invention provides a network system, including:

a software defined networking SDN controller, a mobile node, a mobile access gateway MAG, and a local mobility anchor LMA; where

the mobile node is configured to send a data link layer L2 attach request message to the MAG when the mobile node needs to access the MAG, where the L2 attach request message includes an ID of the mobile node;

the MAG is configured to: add the received L2 attach request message to a bearer message, and forward the bearer message to the SDN controller;

the SDN controller is configured to: send, to each of the MAG and the LMA, a message for establishing a tunnel between the MAG and the LMA, and send, to each of the MAG and the LMA, a message for adjusting a flow entry of the mobile node;

the MAG is configured to: complete establishment of the tunnel on the MAG side according to the received message for establishing a tunnel between the MAG and the LMA, and adjust, according to the received message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the MAG;

the LMA is configured to: complete establishment of the tunnel on the LMA side according to the message for establishing a tunnel between the MAG and the LMA, and adjust, according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the LMA;

the SDN controller is further configured to: after establishment of the tunnel between the MAG and the LMA succeeds, configure HNP(s) for the mobile node, encapsulate the HNP(s) into a router advertisement message, and send the router advertisement message to the MAG; and

the mobile node is further configured to receive the router advertisement message forwarded by the MAG, to register with a network.

With reference to the fourth aspect of the embodiments of the present invention, in a first implementation manner of the fourth aspect of the embodiments of the present invention, the SDN controller is further configured to: send a first establishment message and a first adjustment message to the MAG, and send a second establishment message and a second adjustment message to the LMA;

the MAG is configured to: establish a tunnel interface on the MAG side according to the received first establishment message, and add a first flow entry of the mobile node according to the first adjustment message; and

the LMA is configured to: establish a tunnel interface on the LMA side according to the received second establishment message, and add a second flow entry of the mobile node according to the second adjustment message.

With reference to the first implementation manner of the fourth aspect of the embodiments of the present invention, in a second implementation manner of the fourth aspect of the embodiments of the present invention, content of the first flow entry includes: a first matching entry: a source address prefix is the HNP(s) of the mobile node; an operation corresponding to the first matching entry: forwarding through a MAG-LMA tunnel interface; a second matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the second matching entry: forwarding to a mobile node interface link; and

content of the second flow entry includes: a third matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the third matching entry: forwarding through an LMA-MAG tunnel interface.

With reference to the fourth aspect of the embodiments of the present invention, or the first implementation manner of the fourth aspect, or the second implementation manner of the fourth aspect, in a third implementation manner of the fourth aspect of the embodiments of the present invention, the mobile node is further configured to send packet data to the accessed MAG after the mobile node is registered with the network;

the MAG is configured to: match a source address prefix included in the received packet data with the first matching entry in the first flow entry in the MAG, and if the matching succeeds, forward the packet data to the LMA through the tunnel between the MAG and the LMA according to the first flow entry; and

the LMA is configured to forward the received packet data to the network.

With reference to the fourth aspect of the embodiments of the present invention, or the first implementation manner of the fourth aspect, or the second implementation manner of the fourth aspect, in a fourth implementation manner of the fourth aspect of the embodiments of the present invention, the LMA is configured to: after the mobile node is registered with the network, receive packet data from the network, match a destination address prefix included in the packet data with the third matching entry in the second flow entry in the LMA, and if the matching succeeds, forward the packet data to the MAG through the tunnel between the MAG and the LMA according to the second flow entry; and

the MAG is configured to: match the destination address prefix included in the packet data with the second matching entry in the first flow entry in the MAG, and if the matching succeeds, forward the packet data to the mobile node through the tunnel between the MAG and the LMA according to the first flow entry.

A fifth aspect of the embodiments of the present invention provides a software defined networking SDN controller, including:

a processor for processing a message received from each network element, a receiver, and a transmitter, where

the receiver is configured to receive a first bearer message that is forwarded by a first MAG in multiple mobile access gateways MAGs and that carries a first data link layer L2 attach request message, so that a mobile node requests to register with a network, where the first L2 attach request message is sent by the mobile node to the first MAG to request to access the first MAG, and the first L2 attach request message includes an ID of the mobile node;

the transmitter is configured to send, to each of the first MAG and an LMA, a message for establishing a tunnel between the first MAG and the local mobility anchor LMA, to establish the tunnel between the first MAG and the LMA;

the transmitter is further configured to send, to each of the first MAG and the LMA, a message for adjusting a flow entry of the mobile node;

the processor is configured to: when establishment of the tunnel between the first MAG and the LMA succeeds,

configure HNP(s) for the mobile node, and encapsulate the HNP(s) into a router advertisement message; and

the transmitter is further configured to send the router advertisement message to the first MAG, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the first MAG

A sixth aspect of the embodiments of the present invention provides a mobile access gateway MAG, including a processor, a transmitter, and a receiver, where

the receiver is configured to receive a data link layer L2 attach request message sent by a mobile node, where the L2 attach request message includes an ID of the mobile node;

the transmitter is configured to: add the L2 attach request message to a bearer message, and forward the bearer message to a software defined networking SDN controller;

the receiver is further configured to receive a message that is sent by the SDN controller and for establishing a tunnel between the MAG and a local mobility anchor LMA;

the processor is configured to complete establishment of the tunnel on the MAG side according to the message for establishing a tunnel between the MAG and the LMA;

the receiver is further configured to receive a message that is sent by the SDN controller and for adjusting a flow entry of the mobile node;

the processor is further configured to adjust, according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the MAG; and

the transmitter is further configured to: when establishment of the tunnel between the MAG and the LMA succeeds, forward a router advertisement message received from the SDN controller to the mobile node, so that the mobile node is registered with a network, where the router advertisement message includes HNP(s) configured by the SDN controller for the mobile node.

A seventh aspect of the embodiments of the present invention provides a local mobility anchor LMA, including a processor and a receiver, where

the receiver is configured to: after a software defined networking SDN controller receives a bearer message sent by a mobile access gateway MAG, receive a message that is sent by the SDN controller and for establishing a tunnel between the MAG and the LMA, where the bearer message carries a data link layer L2 attach request message, the L2 attach request message is sent by a mobile node to the MAG to request to access the MAG, and the L2 attach request message includes an ID of the mobile node;

the processor is configured to complete establishment of the tunnel on the LMA side according to the message for establishing a tunnel between the MAG and the LMA;

the receiver is further configured to receive a message that is sent by the SDN controller and for adjusting a flow entry of the mobile node; and

the processor is further configured to adjust, according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the LMA.

An eighth aspect of the embodiments of the present invention provides a binding registration method, including:

receiving, by a software defined networking SDN controller, a first bearer message that is forwarded by a first MAG in multiple mobile access gateways MAGs and that carries a first data link layer L2 attach request message, to request a mobile node to register with a network, where the first L2 attach request message is sent by the mobile node to the first MAG to request to access the first MAG, and the first L2 attach request message includes an ID of the mobile node;

sending, by the SDN controller to each of the first MAG and an LMA, a message for establishing a tunnel between the first MAG and the local mobility anchor LMA, to establish the tunnel between the first MAG and the LMA;

sending, by the SDN controller to each of the first MAG and the LMA, a message for adjusting a flow entry of the mobile node; and

if establishment of the tunnel between the first MAG and the LMA succeeds, configuring, by the SDN controller, HNP(s) for the mobile node, encapsulating the HNP(s) into a router advertisement message, and sending the router advertisement message to the first MAG, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the first MAG

With reference to the eighth aspect of the embodiments of the present invention, in a first implementation manner of the eighth aspect of the embodiments of the present invention, the sending, by the SDN controller to each of the first MAG and an LMA, a message for establishing a tunnel between the first MAG and the LMA is specifically:

sending, by the SDN controller, a first establishment message to the first MAG, where the first establishment message is used to instruct the first MAG to establish a tunnel interface on the first MAG side, and the first establishment message includes configuration information for establishing the tunnel interface on the first MAG side; and

sending, by the SDN controller, a second establishment message to the LMA, where the second establishment message is used to instruct the LMA to establish a tunnel interface on the LMA side, and the second establishment message includes configuration information for establishing the tunnel interface on the LMA side; and

the sending, by the SDN controller to each of the first MAG and the LMA, a message for adjusting a flow entry of the mobile node is specifically:

sending, by the SDN controller, a first adjustment message to the first MAG, where the first adjustment message is used to instruct the first MAG to add a first flow entry of the mobile node; and

sending, by the SDN controller, a second adjustment message to the LMA, where the second adjustment message is used to instruct the LMA to add a second flow entry of the mobile node.

With reference to the first implementation manner of the eighth aspect of the embodiments of the present invention, in a second implementation manner of the eighth aspect of the embodiments of the present invention,

the first flow entry is used to instruct the first MAG to forward data according to content of the first flow entry; and

the second flow entry is used to instruct the LMA to forward data according to content of the second flow entry.

With reference to the second implementation manner of the eighth aspect of the embodiments of the present invention, in a third implementation manner of the eighth aspect of the embodiments of the present invention, the content of the first flow entry includes: a first matching entry: a source address prefix is the HNP(s) of the mobile node; an operation corresponding to the first matching entry: forwarding through a first MAG-LMA tunnel interface; a second matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the second matching entry: forwarding to a mobile node interface link; and

the content of the second flow entry includes: a third matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the third matching entry: forwarding through an LMA-first MAG tunnel interface.

With reference to the eighth aspect of the embodiments of the present invention, or the first implementation manner of the eighth aspect, or the second implementation manner of the eighth aspect, or the third implementation manner of the eighth aspect, in a fourth implementation manner of the eighth aspect of the embodiments of the present invention, the method further includes:

when the mobile node needs to be switched from the first MAG to a second MAG in the multiple MAGs, receiving, by the SDN controller, a second bearer message that is forwarded by the second MAG and that carries a second L2 attach request message, to request the mobile node to register with the network, where the second L2 attach request message is sent by the mobile node to the second MAG to request to access the second MAG, and the second L2 attach request message includes the ID of the mobile node;

sending, by the SDN controller to each of the second MAG and the LMA, a message for establishing a tunnel between the second MAG and the LMA, to establish the tunnel between the second MAG and the LMA;

sending, by the SDN controller to each of the second MAG and the LMA, the message for adjusting a flow entry of the mobile node; and

if establishment of the tunnel between the second MAG and the LMA succeeds, configuring, by the SDN controller, the HNP(s) for the mobile node, encapsulating the HNP(s) into the router advertisement message, and sending the router advertisement message to the second MAG, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the second MAG

With reference to the fourth implementation manner of the eighth aspect of the embodiments of the present invention, in a fifth implementation manner of the eighth aspect of the embodiments of the present invention, the sending, by the SDN controller to each of the second MAG and the LMA, a message for establishing a tunnel between the second MAG and the LMA is specifically:

sending, by the SDN controller, a third establishment message to the second MAG, where the third establishment message is used to instruct the second MAG to establish a tunnel interface on the second MAG side, and the third establishment message includes configuration information for establishing the tunnel interface on the second MAG side; and

sending, by the SDN controller, a fourth establishment message to the LMA, where the fourth establishment message is used to instruct the LMA to establish a tunnel interface on the LMA side, and the fourth establishment message includes configuration information for establishing the tunnel interface on the LMA side; and

the sending, by the SDN controller to each of the first MAG and the LMA, the message for adjusting a flow entry of the mobile node is specifically:

sending, by the SDN controller, a third adjustment message to the second MAG, where the third adjustment message is used to instruct the second MAG to add a third flow entry of the mobile node; and

sending, by the SDN controller, a fourth adjustment message to the LMA, where the fourth adjustment message is used to instruct the LMA to add a fourth flow entry of the mobile node.

With reference to the fifth implementation manner of the eighth aspect of the embodiments of the present invention, in a sixth implementation manner of the eighth aspect of the embodiments of the present invention, the third flow entry is used to instruct the second MAG to forward data according to content of the third flow entry; and

the fourth flow entry is used to instruct the LMA to forward data according to content of the fourth flow entry.

With reference to the sixth implementation manner of the eighth aspect of the embodiments of the present invention, in a seventh implementation manner of the eighth aspect of the embodiments of the present invention, the content of the third flow entry includes: a fourth matching entry: a source address prefix is the HNP(s) of the mobile node; an operation corresponding to the fourth matching entry: forwarding through a second MAG-LMA tunnel interface; a fifth matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the fifth matching entry: forwarding to the mobile node interface link; and

the content of the fourth flow entry includes: a sixth matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the sixth matching entry: forwarding through an LMA-second MAG tunnel interface.

A ninth aspect of the embodiments of the present invention provides a data forwarding method, including:

receiving, by a mobile access gateway MAG, a data link layer L2 attach request message sent by a mobile node, where the L2 attach request message includes an ID of the mobile node;

adding, by the MAG, the L2 attach request message to a bearer message, and forwarding the bearer message to a software defined networking SDN controller;

receiving, by the MAG, a message that is sent by the SDN controller and for establishing a tunnel between the MAG and a local mobility anchor LMA, and completing establishment of the tunnel on the MAG side according to the message for establishing a tunnel between the MAG and the LMA;

receiving, by the MAG, a message that is sent by the SDN controller and for adjusting a flow entry of the mobile node, and adjusting, according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the MAG; and

if establishment of the tunnel between the MAG and the LMA succeeds, forwarding, by the MAG, a router advertisement message received from the SDN controller to the mobile node, so that the mobile node is registered with a network, where the router advertisement message includes HNP(s) configured by the SDN controller for the mobile node.

With reference to the ninth aspect of the embodiments of the present invention, in a first implementation manner of the ninth aspect of the embodiments of the present invention, the completing establishment of the tunnel on the MAG side according to the message for establishing a tunnel between the MAG and the LMA is specifically:

establishing, by the MAG, a tunnel interface on the MAG side according to the message for establishing a tunnel between the MAG and the LMA; and

the adjusting, by the MAG according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the MAG is specifically:

adding, by the MAG, a first flow entry of the mobile node according to the message for adjusting a flow entry of the mobile node.

With reference to the first implementation manner of the ninth aspect of the embodiments of the present invention, in a second implementation manner of the ninth aspect of the embodiments of the present invention, content of the first flow entry includes: a first matching entry: a source address prefix is the HNP(s) of the mobile node; an operation corresponding to the first matching entry: forwarding through a MAG-LMA tunnel interface; a second matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the second matching entry: forwarding to a mobile node interface link.

With reference to the first implementation manner of the ninth aspect of the embodiments of the present invention, or the second implementation manner of the ninth aspect, in a third implementation manner of the ninth aspect of the embodiments of the present invention, the method further includes:

after the mobile node is registered with the network, receiving, by the MAG, packet data sent by the mobile node, and matching a source address prefix included in the packet data with the first matching entry in the first flow entry in the MAG; and

if the matching succeeds, forwarding, by the MAG, the packet data to the LMA through the tunnel between the MAG and the LMA according to the first flow entry, so that the LMA forwards the packet data to the network.

A tenth aspect of the embodiments of the present invention provides a data forwarding method, including:

after a software defined networking SDN controller receives a bearer message sent by a mobile access gateway MAG, receiving, by a local mobility anchor LMA, a message that is sent by the SDN controller and for establishing a tunnel between the MAG and the LMA, and completing establishment of the tunnel on the LMA side according to the message for establishing a tunnel between the MAG and the LMA, where the bearer message carries a data link layer L2 attach request message, the L2 attach request message is sent by a mobile node to the MAG to request to access the MAG, and the L2 attach request message includes an ID of the mobile node; and

receiving, by the LMA, a message that is sent by the SDN controller and for adjusting a flow entry of the mobile node, and adjusting, according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the LMA.

With reference to the tenth aspect of the embodiments of the present invention, in a first implementation manner of the tenth aspect of the embodiments of the present invention, the completing establishment of the tunnel on the LMA side according to the message for establishing a tunnel between the MAG and the LMA is specifically:

establishing, by the LMA, a tunnel interface on the LMA side according to the message for establishing a tunnel between the MAG and the LMA; and

the adjusting, by the LMA according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the LMA is specifically:

adding, by the LMA, a second flow entry of the mobile node according to the message for adjusting a flow entry of the mobile node.

With reference to the first implementation manner of the tenth aspect of the embodiments of the present invention, in a second implementation manner of the tenth aspect of the embodiments of the present invention, content of the second flow entry includes: a third matching entry: a destination address prefix is an HNP(s) of the mobile node; and an operation corresponding to the third matching entry: forwarding through an LMA-MAG tunnel interface.

With reference to the first implementation manner of the tenth aspect of the embodiments of the present invention, or the second implementation manner of the tenth aspect, in a third implementation manner of the tenth aspect of the embodiments of the present invention, the method further includes:

receiving, by the LMA, packet data from a network after establishment of the tunnel between the MAG and the LMA succeeds and the mobile node receives a router advertisement message to register with the network;

matching, by the LMA, a destination address prefix included in the packet data with the third matching entry in the second flow entry in the LMA; and

if the matching succeeds, forwarding, by the LMA, the packet data to the MAG through the tunnel between the MAG and the LMA according to the second flow entry, so that the MAG forwards the packet data to the mobile node according to a first flow entry in the MAG

With reference to the third implementation manner of the tenth aspect of the embodiments of the present invention, in a fourth implementation manner of the tenth aspect of the embodiments of the present invention, content of the first flow entry includes: a first matching entry: a source address prefix is the HNP(s) of the mobile node; an operation corresponding to the first matching entry: forwarding through a MAG-LMA tunnel interface; a second matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the second matching entry: forwarding to a mobile node interface link.

It may be learned from the foregoing technical solutions that the embodiments of the present invention have the following advantages:

In the embodiments of the present invention, an SDN controller includes: a first receiving unit, a first sending unit, a second sending unit, a configuration and encapsulation unit, and a third sending unit, where the first receiving unit is configured to receive a first bearer message that is forwarded by a first MAG in multiple MAGs and that carries a first L2 attach request message, so that a mobile node requests to register with a network; the first sending unit is configured to send, to each of the first MAG and an LMA, a message for establishing a tunnel between the first MAG and the LMA, to establish the tunnel between the first MAG and the LMA; the second sending unit is configured to send, to each of the first MAG and the LMA, a message for adjusting a flow entry of the mobile node; the configuration and encapsulation unit is configured to: when establishment

of the tunnel between the first MAG and the LMA succeeds, configure an HNP(s) for the mobile node, and encapsulate the HNP(s) into a router advertisement message; and the third sending unit is configured to send the router advertisement message to the first MAG, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the first MAG. In this way, the SDN controller instructs the network element devices LMA and MAG to establish the tunnel, and then the network element devices LMA and MAG may forward data according to flow entries delivered by the SDN controller, so that the network element devices do not need to negotiate with each other. In addition, in comparison with the prior art, the network element devices LMA and MAG may perform operations according to instructions of the SDN controller, and therefore complex control functions are simplified, and the network element devices LMA and MAG are applicable to any Internet Protocol (IP), thereby reducing costs in network construction.

BRIEF DESCRIPTION OF DRAWINGS

To describe the technical solutions in the embodiments of the present invention more clearly, the following briefly describes the accompanying drawings required for describing the embodiments or the prior art. Apparently, the accompanying drawings in the following description show merely some embodiments of the present invention, and persons of ordinary skill in the art may still derive other drawings from these accompanying drawings without creative efforts.

FIG. **1** is a schematic diagram of an embodiment of an SDN controller in the embodiments of the present invention;

FIG. **2** is a schematic diagram of another embodiment of an SDN controller in the embodiments of the present invention;

FIG. **3** is a schematic diagram of an embodiment of a MAG in the embodiments of the present invention;

FIG. **4** is a schematic diagram of another embodiment of a MAG in the embodiments of the present invention;

FIG. **5** is a schematic diagram of an embodiment of an LMA in the embodiments of the present invention;

FIG. **6** is a schematic diagram of another embodiment of an LMA in the embodiments of the present invention;

FIG. **7** is a schematic diagram of an embodiment of a network system in the embodiments of the present invention;

FIG. **8** is a schematic diagram of signaling interworking between each network element in a network system and a network in the embodiments of the present invention;

FIG. **9** is a schematic diagram of an embodiment of an SDN controller in the embodiments of the present invention;

FIG. **10** is a schematic diagram of an embodiment of a MAG in the embodiments of the present invention;

FIG. **11** is a schematic diagram of an embodiment of an LMA in the embodiments of the present invention;

FIG. **12** is a schematic diagram of an embodiment of a binding registration method in the embodiments of the present invention;

FIG. **13** is a schematic diagram of another embodiment of a binding registration method in the embodiments of the present invention;

FIG. **14** is a schematic diagram of an embodiment of a data forwarding method in the embodiments of the present invention;

FIG. **15** is a schematic diagram of another embodiment of a data forwarding method in the embodiments of the present invention;

FIG. **16** is a schematic diagram of an embodiment of a data forwarding method in the embodiments of the present invention; and

FIG. **17** is a schematic diagram of another embodiment of a data forwarding method in the embodiments of the present invention.

DESCRIPTION OF EMBODIMENTS

To make objectives, technical solutions and advantages of the present invention clearer, the following further describes implementation manners of the present invention in detail with reference to accompanying drawings. Apparently, the described embodiments are merely some but not all of the embodiments of the present invention. All other embodiments obtained by persons of ordinary skill in the art based on the embodiments of the present invention without creative efforts shall fall within the protection scope of the present invention.

Embodiments of the present invention provide a binding registration method, a data forwarding method, a related device, and a network system, so that network element devices do not need to negotiate with each other. In addition, in comparison with the prior art, network element devices LMA and MAG may perform operations according to instructions of an SDN controller, and therefore complex control functions are simplified, and the network element devices LMA and MAG are applicable to any IP, thereby reducing costs in network construction.

Referring to FIG. **1**, FIG. **1** shows an embodiment of a software defined networking (SDN) controller in the embodiments of the present invention. The SDN controller includes: a first receiving unit **101**, a first sending unit **102**, a second sending unit **103**, a configuration and encapsulation unit **104**, and a third sending unit **105**.

The first receiving unit **101** is configured to receive a first bearer message that is forwarded by a first MAG in multiple MAGs and that carries a first L2 attach request message, to request a mobile node to register with a network, where the first L2 attach request message is sent by the mobile node to the first MAG to request to access the first MAG, and the first L2 attach request message includes an ID of the mobile node.

The first sending unit **102** is configured to send, to each of the first MAG and an LMA, a message for establishing a tunnel between the first MAG and the LMA, to establish the tunnel between the first MAG and the LMA.

The second sending unit **103** is configured to send, to each of the first MAG and the LMA, a message for adjusting a flow entry of the mobile node.

The configuration and encapsulation unit **104** is configured to: when establishment of the tunnel between the first MAG and the LMA succeeds, configure an HNP(s) for the mobile node, and encapsulate the HNP(s) into a router advertisement message.

The third sending unit **105** is configured to send the router advertisement message to the first MAG, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the first MAG

In actual application, the message for establishing a tunnel between the first MAG and the LMA may include configuration information for establishing the tunnel, and tunnels of different types have different configuration information. The flow entry of the mobile node is a flow entry related to the mobile node, and the message for adjusting a flow entry of the mobile node is used to adjust flow entries

of the mobile node in the first MAG and the LMA. Further, when the first MAG and the LMA each complete establishment of the tunnel and adjustment of the flow entries of the mobile node, it indicates that establishment of the tunnel between the first MAG and the LMA succeeds. In this case, the SDN controller may separately receive responses fed back by the first MAG and the LMA, so that the SDN controller is notified that establishment of the tunnel succeeds.

In this embodiment, an SDN controller includes: a first receiving unit, a first sending unit, a second sending unit, a configuration and encapsulation unit, and a third sending unit, where the first receiving unit is configured to receive a first bearer message that is forwarded by a first MAG in multiple MAGs and that carries a first L2 attach request message, so that a mobile node requests to register with a network; the first sending unit is configured to send, to each of the first MAG and an LMA, a message for establishing a tunnel between the first MAG and the LMA, to establish the tunnel between the first MAG and the LMA; the second sending unit is configured to send, to each of the first MAG and the LMA, a message for adjusting a flow entry of the mobile node; the configuration and encapsulation unit is configured to: when establishment of the tunnel between the first MAG and the LMA succeeds, configure an HNP(s) for the mobile node, and encapsulate the HNP(s) into a router advertisement message; and the third sending unit is configured to send the router advertisement message to the first MAG, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the first MAG In this way, the SDN controller instructs the network element devices LMA and MAG to establish the tunnel, and then the network element devices LMA and MAG may forward data according to flow entries delivered by the SDN controller, so that the network element devices do not need to negotiate with each other. In addition, in comparison with the prior art, the network element devices LMA and MAG may perform operations according to instructions of the SDN controller, and therefore complex control functions are simplified, and the network element devices LMA and MAG are applicable to any Internet Protocol (IP), thereby reducing costs in network construction.

To better understand the foregoing embodiment, the following uses a specific embodiment to describe interaction between units or components included in an SDN controller and describe a data interaction manner of the SDN controller. Referring to FIG. **2**, the SDN controller includes:

- a first receiving unit **201**, a first sending unit **202**, a second sending unit **203**, a configuration and encapsulation unit **204**, a third sending unit **205**, and a second receiving unit **206**.

The first receiving unit **201** receives a first bearer message that is forwarded by a first MAG in multiple MAGs and that carries a first L2 attach request message, to request a mobile node to register with a network, where the first L2 attach request message is sent by the mobile node to the first MAG to request to access the first MAG, and the first L2 attach request message includes an ID of the mobile node. In actual application, the mobile node determines, according to a requirement, to access the first MAG in the multiple MAGs, and in this case, the first MAG receives the first L2 attach request message. Because there is no matched flow entry in the first MAG, the first MAG sends the SDN controller the first bearer message that carries the first L2 attach request message, and then instructs the first sending unit **202** and the second sending unit **203** to perform a sending operation.

In an actual application scenario, the L2 attach request message may be carried in a packet in form in this embodiment.

The first sending unit **202** sends a first establishment message to the first MAG, and sends a second establishment message to the LMA, where the first establishment message is used to instruct the first MAG to establish a tunnel interface on the first MAG side, and the second establishment message is used to instruct the LMA to establish a tunnel interface on the LMA side. In actual application, the first establishment message includes configuration information for establishing the tunnel interface on the first MAG side, the second establishment message includes configuration information for establishing the tunnel interface on the LMA side, and tunnels of different types have different configuration information.

In an actual application scenario, establishment of an IP-in-IP tunnel is used as an example for description. In this case, the first establishment message and the second establishment message mainly include information in which an address Proxy-CoA **1** on the first MAG side and an address LMAA on the LMA side are encapsulated, where Proxy-CoA **1** is an address of the first MAG, and LMAA is an address of the LMA.

The second sending unit **203** sends a first adjustment message to the first MAG, and sends a second adjustment message to the LMA, where the first adjustment message is used to instruct the first MAG to add a first flow entry of the mobile node, and the second adjustment message is used to instruct the LMA to add a second flow entry of the mobile node.

Content of the first flow entry includes: a first matching entry: a source address prefix is an HNP(s) of the mobile node; an operation corresponding to the first matching entry: forwarding through a first MAG-LMA tunnel interface; a second matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the second matching entry: forwarding to a mobile node interface link. Content of the second flow entry includes: a third matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the third matching entry: forwarding through an LMA-first MAG tunnel interface.

If establishment of the tunnel between the first MAG and the LMA succeeds, the configuration and encapsulation unit **204** configures an HNP(s) for the mobile node, encapsulates the HNP(s) into a router advertisement message, and sends the router advertisement message to the third sending unit **205**. In actual application, when the first MAG and the LMA each complete establishment of the tunnel and adjustment of the flow entries of the mobile node, it indicates that establishment of the tunnel between the first MAG and the LMA succeeds. In this case, the SDN controller may separately receive responses fed back by the first MAG and the LMA, so that the SDN controller is notified that establishment of the tunnel succeeds.

The third sending unit **205** sends the router advertisement message to the first MAG, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the first MAG. In actual application, when the mobile node receives the router advertisement message from the first MAG, it indicates that the mobile node is registered with the network. In actual application, if the mobile node does not receive the router advertisement message, the mobile node may send a router solicitation (RS) message to the first MAG to request to acquire the HNP(s), and then the first MAG may forward the

received RS message to the SDN controller, so that the SDN controller delivers the HNP(s).

When the mobile node needs to be switched from the first MAG to a second MAG in the multiple MAGs, the second receiving unit **206** receives a second bearer message that is forwarded by the second MAG and that carries a second L2 attach request message, to request the mobile node to register with the network, and then instructs the first sending unit **202** and the third sending unit **203** to perform a sending operation, where the second L2 attach request message is sent by the mobile node to the second MAG to request to access the second MAG, and the second L2 attach request message includes the ID of the mobile node. In actual application, the mobile node may be switched to the second MAG in the multiple MAGs, and in this case, the second MAG receives the second L2 attach request message. Because there is no matched flow entry in the second MAG, the second MAG sends the SDN controller the second bearer message that carries the second L2 attach request message.

The first sending unit **202** sends, to each of the second MAG and the LMA, a message for establishing a tunnel between the second MAG and the LMA, to establish the tunnel between the second MAG and the LMA. In application, the message for establishing a tunnel between the second MAG and the LMA may include configuration information for establishing the tunnel, and tunnels of different types have different configuration information. Specifically, the first sending unit **202** sends a third establishment message to the second MAG, and sends a fourth establishment message to the LMA, where the third establishment message is used to instruct the second MAG to establish a tunnel interface on the second MAG side, and the fourth establishment message is used to instruct the LMA to establish a tunnel interface on the LMA side.

In an actual application scenario, establishment of an IP-in-IP tunnel is used as an example for description. In this case, the third establishment message and the fourth establishment message mainly include information in which an address Proxy-CoA **2** on the second MAG side and the address LMAA on the LMA side are encapsulated, where Proxy-CoA **2** is an address of the second MAG, and LMAA is the address of the LMA.

In actual application, the original tunnel between the first MAG and the LMA is changed to the tunnel between the second MAG and the LMA. In this case, the SDN controller may send a tunnel teardown instruction to each of the first MAG and the LMA, to tear down the tunnel between the first MAG and the LMA.

The second sending unit **203** sends, to each of the second MAG and the LMA, a message for adjusting a flow entry of the mobile node. In actual application, the message of the flow entry of the mobile node is a flow entry related to the mobile node, and the message for adjusting a flow entry of the mobile node is used to adjust flow entries of the mobile node in the first MAG and the LMA. Specifically, the second sending unit **203** sends a third adjustment message to the second MAG, and sends a fourth adjustment message to the LMA, where the third adjustment message is used to instruct the second MAG to add a third flow entry of the mobile node, and the fourth adjustment message is used to instruct the LMA to add a fourth flow entry of the mobile node.

The third flow entry is used to instruct the second MAG to forward data according to content of the third flow entry, and the fourth flow entry is used to instruct the LMA to forward data according to content of the fourth flow entry. The content of the third flow entry includes: a fourth matching entry: a source address prefix is the HNP(s) of the mobile node; an operation corresponding to the fourth matching entry: forwarding through a second MAG-LMA tunnel interface; a fifth matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the fifth matching entry: forwarding to the mobile node interface link. The content of the fourth flow entry includes: a sixth matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the sixth matching entry: forwarding through an LMA-second MAG tunnel interface.

When establishment of the tunnel between the second MAG and the LMA succeeds, the configuration and encapsulation unit **204** configures the HNP(s) for the mobile node, and encapsulates the HNP(s) into the router advertisement message. In actual application, when the second MAG and the LMA each complete establishment of the tunnel and adjustment of the flow entries of the mobile node, it indicates that establishment of the tunnel between the second MAG and the LMA succeeds. In this case, the SDN controller may separately receive responses fed back by the second MAG and the LMA, so that the SDN controller is notified that establishment of the tunnel succeeds.

When establishment of the tunnel between the second MAG and the LMA succeeds, the third sending unit **205** sends the router advertisement message to the second MAG, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the second MAG, where the router advertisement message includes the HNP(s) configured by the SDN controller for the mobile node.

In this embodiment, a first sending subunit **2021** instructs network element devices LMA and first MAG to establish a tunnel, and a second sending subunit **2031** sends a flow entry of a mobile node to each of the first MAG and the LMA, so that the network element devices do not need to perform complex tunnel parameter negotiation with each other. In addition, in comparison with the prior art, the network element devices LMA and MAG may perform operations according to instructions of an SDN controller without complex control functions, and therefore the network element devices LMA and MAG are applicable to any Internet Protocol (IP), thereby reducing costs in network construction. When the mobile node needs to be switched from the first MAG to a second MAG, a first sending unit **202** may further instruct the network element devices LMA and second MAG to establish a tunnel, and a second sending unit **203** sends a flow entry of the mobile node to each of the second MAG and the LMA, and therefore the LMA and a different MAG do not need to perform a frequent and complex signaling interworking process when the mobile node moves and is switched to the different MAG, thereby increasing a processing speed of the network element device, and improving network bandwidth utilization.

Referring to FIG. **3**, FIG. **3** shows an embodiment of a MAG in the embodiments of the present invention. The MAG includes: a first receiving unit **301**, a first forwarding unit **302**, a second receiving unit **303**, an establishment unit **304**, an adjustment unit **305**, and a second forwarding unit **306**.

The first receiving unit **301** is configured to receive an L2 attach request message sent by a mobile node, where the L2 attach request message includes an ID of the mobile node.

The first forwarding unit **302** is configured to: add the L2 attach request message to a bearer message, and forward the bearer message to an SDN controller.

The second receiving unit **303** is configured to receive a message that is sent by the SDN controller and for establishing a tunnel between the MAG and a local mobility anchor LMA.

The establishment unit **304** is configured to complete establishment of the tunnel on the MAG side according to the message for establishing a tunnel between the MAG and the LMA.

The second receiving unit **303** is further configured to receive a message that is sent by the SDN controller and for adjusting a flow entry of the mobile node.

The adjustment unit **305** is configured to adjust, according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the MAG

The second forwarding unit **306** is configured to: when establishment of the tunnel between the MAG and the LMA succeeds, forward a router advertisement message received from the SDN controller to the mobile node, so that the mobile node is registered with a network, where the router advertisement message includes an HNP(s) configured by the SDN controller for the mobile node.

In this embodiment, the message for establishing a tunnel between the MAG and the LMA may include configuration information for establishing the tunnel, and tunnels of different types have different configuration information. The message of the flow entry of the mobile node is a flow entry related to the mobile node.

In actual application, the SDN controller simultaneously sends the LMA the message for establishing a tunnel between the LMA and the MAG, and the LMA may complete establishment of the tunnel on the LMA side according to the message for establishing a tunnel between the LMA and the MAG. The SDN controller also sends the LMA the message for adjusting a flow entry of the mobile node, so that the LMA adjusts, according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the LMA. Then the second forwarding unit **306** may feed back a response to the SDN controller, and the LMA may also feed back a response to the SDN controller, to notify the SDN controller that establishment of the tunnel between the MAG and the LMA succeeds.

In this embodiment, a first receiving unit **302**, a second receiving unit **303**, an establishment unit **304**, and an adjustment unit **305** add an L2 attach request message to a bearer message, forward the bearer message to an SDN controller, then complete establishment of a tunnel on a MAG side according to a message that is sent by the SDN controller and for establishing a tunnel between the MAG and an LMA, and adjust, according to a message that is sent by the SDN controller and for adjusting a flow entry of a mobile node, a flow entry that is of the mobile node and stored in the MAG, so that the MAG and the LMA do not need to negotiate with each other to establish the tunnel. In addition, in comparison with the prior art, the network element device MAG may perform an operation according to an instruction of the SDN controller, and therefore a complex control function is simplified, and the network element device MAG is applicable to any IP, thereby reducing costs in network construction.

To better understand the foregoing embodiment, the following uses a specific embodiment to describe interaction between units or components included in a MAG and describe a data interaction manner of the MAG. Referring to FIG. **4**, the MAG includes:

a first receiving unit **401**, a first forwarding unit **402**, a second receiving unit **403**, an establishment unit **404**, an adjustment unit **405**, a second forwarding unit **406**, a third receiving unit **407**, a matching unit **408**, and a third forwarding unit **409**.

The first receiving unit **401** receives an L2 attach request message sent by a mobile node, where the L2 attach request message includes an ID of the mobile node. In actual application, the mobile node sends the L2 attach request message to the MAG so as to access the MAG

Because there is no matched flow entry when the MAG receives the L2 attach request message, the first forwarding unit **402** adds the L2 attach request message to a bearer message, and forwards the bearer message to an SDN controller.

The second receiving unit **403** receives an establishment message and an adjustment message that are sent by the SDN controller, and then sends the establishment message to the establishment unit **404** and sends the adjustment message to the adjustment unit **405**. In actual application, the establishment message is used to instruct the MAG to establish a tunnel interface on the MAG side in a tunnel between the MAG and an LMA, and the establishment message includes configuration information for establishing the tunnel interface on the MAG side.

The establishment unit **404** establishes the tunnel interface on the MAG side according to the establishment message. In actual application, the network element device LMA may also receive another establishment message sent by the SDN controller, and the LMA establishes a tunnel interface on the LMA side according to the another establishment message, where the another establishment message includes configuration information for establishing the tunnel interface on the LMA side.

The adjustment unit **405** adds a first flow entry of the mobile node according to the adjustment message, where content of the first flow entry includes: a first matching entry: a source address prefix is an HNP(s) of the mobile node; an operation corresponding to the first matching entry: forwarding through a MAG-LMA tunnel interface; a second matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the second matching entry: forwarding to a mobile node interface link. In actual application, the MAG may forward data according to the first flow entry.

In actual application, the network element device LMA may also receive another adjustment message sent by the SDN controller, and the LMA may add a second flow entry according to the another adjustment message, where content of the second flow entry includes: a third matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the third matching entry: forwarding through an LMA-MAG tunnel interface.

When establishment of the tunnel between the MAG and the LMA succeeds, the second forwarding unit **406** forwards a router advertisement message received from the SDN controller to the mobile node, so that the mobile node is registered with a network, where the router advertisement message includes an HNP(s) configured by the SDN controller for the mobile node. In actual application, the establishment unit **404** and the adjustment unit **405** may notify the second forwarding unit **407** when completing operations. In this case, the second forwarding unit may first feed back a response to the SDN controller. Certainly, after the LMA completes establishment of the tunnel interface on the LMA side and adjustment of a flow entry that is of the mobile node and stored in the LMA, the LMA may also feed back a

response to the SDN controller, to notify the SDN controller that establishment of the tunnel between the MAG and the LMA succeeds.

In actual application, if the mobile node does not receive the router advertisement message, the mobile node may send a router solicitation (RS) message to the first MAG to request to acquire the HNP(s), and then the first MAG may forward the received RS message to the SDN controller, so that the SDN controller delivers the HNP(s).

After the mobile node is registered with the network, the third receiving unit **407** receives packet data sent by the mobile node, and sends the packet data to the matching unit **408**.

The matching unit **408** matches a source address prefix included in the packet data with the first matching entry in the first flow entry in the MAG, and if the matching succeeds, sends the packet data to the third forwarding unit **409**; or if the matching fails, it indicates that forwarding of the packet data fails. In actual application, if the source address prefix included in the packet data is the HNP(s) of the mobile node, it indicates that matching with the first matching entry in the first flow entry succeeds.

The third forwarding unit **409** forwards the packet data to the LMA through the tunnel between the MAG and the LMA according to the first flow entry, so that the LMA forwards the packet data to the network. In actual application, the LMA forwards the packet data to the network without a flow entry of the mobile node, and the LMA needs to forward the packet data to the network according to another flow entry. How to forward the packet data to the network according to the another flow entry is the prior art, and no further details are provided herein.

For example, the content of the first flow entry includes: the first matching entry: the source address prefix is the HNP(s) of the mobile node; the operation corresponding to the first matching entry: forwarding through the MAG-LMA tunnel interface; the second matching entry: the destination address prefix is the HNP(s) of the mobile node; and the operation corresponding to the second matching entry: forwarding to the mobile node interface link. If the source address prefix included in the packet data received by the third receiving unit **407** is the HNP(s) of the mobile node, it may be determined that matching with the source address prefix of the first matching entry in the first flow entry succeeds. Then the matching unit **408** may perform the operation corresponding to the first matching entry in the first flow entry, that is, forwarding through the MAG-LMA tunnel interface. In this case, the third forwarding unit **409** needs to forward the packet data to the LMA through the MAG-LMA tunnel by using an address of the MAG as a source address and an address of the LMA as a destination address.

In this embodiment, a first forwarding unit **402** adds an L2 attach request message to a bearer message, and forwards the bearer message to an SDN controller, and then an establishment unit **404** and an adjustment unit **405** establish a tunnel on a MAG side according to a message for establishing a tunnel and a message for adjusting a flow entry of a mobile node that are sent by the SDN controller, so that the MAG does not need to negotiate with an LMA. In addition, in comparison with the prior art, the network element device MAG may perform an operation according to an instruction of the SDN controller without a complex control function, and therefore the network element device MAG is applicable to any IP, thereby reducing costs in network construction. When the mobile node has packet data that needs to be sent to a network, a third forwarding unit **409** may forward the packet data to the LMA according to a first flow entry delivered by the SDN controller, so that the LMA forwards the packet data to the network, and the LMA and the MAG do not need to negotiate with each other to forward the packet data, which reduces complex signaling interworking performed when the LMA and the MAG forward the packet data, thereby increasing a processing speed of the network element device, and improving network bandwidth utilization.

Referring to FIG. **5**, FIG. **5** shows an embodiment of an LMA in the embodiments of the present invention. The LMA includes:

a first receiving unit **501**, an establishment unit **502**, and an adjustment unit **503**.

The first receiving unit **501** is configured to: after an SDN controller receives a bearer message sent by a MAG, receive a message that is sent by the SDN controller and for establishing a tunnel between the MAG and the LMA, where the bearer message carries an L2 attach request message, the L2 attach request message is sent by a mobile node to the MAG to request to access the MAG, and the L2 attach request message includes an ID of the mobile node.

The establishment unit **502** is configured to complete establishment of the tunnel on the LMA side according to the message for establishing a tunnel between the MAG and the LMA.

The first receiving unit **501** is further configured to receive a message that is sent by the SDN controller and for adjusting a flow entry of the mobile node.

The adjustment unit **503** is configured to adjust, according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the LMA.

In this embodiment, the message for establishing a tunnel between the MAG and the LMA may include configuration information for establishing the tunnel, and tunnels of different types have different configuration information. The message of the flow entry of the mobile node is a flow entry related to the mobile node.

In actual application, the MAG may also receive another message that is sent by the SDN controller and for establishing a tunnel between the MAG and the LMA, and complete establishment of the tunnel on the MAG side according to the another message for establishing a tunnel between the MAG and the LMA. The SDN controller may also send the MAG the message for adjusting a flow entry of the mobile node, so that the MAG adjusts, according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the MAG. Further, after the LMA completes operations in step **501** and step **502**, the LMA may feed back a response to the SDN controller. Certainly, after the MAG completes establishment of the tunnel on the MAG side and adjustment of the flow entry that is of the mobile node and stored in the MAG, the MAG may also feed back a response to the SDN controller, to notify the SDN controller that establishment of the tunnel between the MAG and the LMA succeeds, and then the SDN controller forwards a router advertisement message to the mobile node by using the MAG. After the mobile node receives the router advertisement message, it indicates that the mobile node is registered with a network, where the router advertisement message includes an HNP(s) configured by the SDN controller for the mobile node.

In this embodiment, an establishment unit **502** completes establishment of a tunnel on an LMA side according to a message for establishing a tunnel between a MAG and the LMA, and an adjustment unit **503** adjusts, according to a

message for adjusting a flow entry of an mobile node, a flow entry that is of the mobile node and stored in the LMA, so that the MAG and the LMA do not need to negotiate with each other to establish the tunnel. In addition, in comparison with the prior art, the network element device LMA may perform an operation according to an instruction of an SDN controller, and therefore a complex control function is simplified, and the network element device LMA is applicable to any IP, thereby reducing costs in network construction.

To better understand the foregoing embodiment, the following uses a specific embodiment to describe interaction between units or components included in an LMA and describe a data interaction manner of the LMA. Referring to FIG. **6**, the LMA includes: a first receiving unit **601**, an establishment unit **602**, an adjustment unit **603**, a second receiving unit **604**, a matching unit **605**, and a forwarding unit **606**.

After an SDN controller receives a bearer message sent by a MAG, the first receiving unit **601** receives an establishment message and an adjustment message that are sent by the SDN controller, and sends the establishment message to the establishment unit **602** and sends the adjustment message to the adjustment unit **603**, where the bearer message carries an L2 attach request message, the L2 attach request message is sent by a mobile node to the MAG to request to access the MAG, and the L2 attach request message includes an ID of the mobile node. In actual application, the establishment message is used to instruct the LMA to establish a tunnel interface on the LMA side in a tunnel between the MAG and the LMA, the establishment message includes configuration information for establishing the tunnel interface on the LMA side, and tunnels of different types have different configuration information.

The establishment unit **602** establishes the tunnel interface on the LMA side according to the establishment message. In actual application, the network element device MAG may also receive another establishment message sent by the SDN controller, and complete establishment of a tunnel interface on the MAG side according to the another establishment message, where the another establishment message includes configuration information for establishing the tunnel interface on the MAG side.

The adjustment unit **603** adds a second flow entry of the mobile node according to the adjustment message, where content of the second flow entry includes: a third matching entry: a destination address prefix is an HNP(s) of the mobile node; and an operation corresponding to the third matching entry: forwarding through an LMA-MAG tunnel interface. In actual application, the LMA may forward data according to the second flow entry, and the network element device MAG may also add a first flow entry according to an instruction of the SDN controller.

Further, after the establishment unit **602** and the adjustment unit **603** complete operations, the LMA may instruct the forwarding unit **606** to feed back a response to the SDN controller. Certainly, after the MAG completes establishment of the tunnel interface on the MAG side and adding of the first flow entry, the MAG may also feed back a response to the SDN controller, to notify the SDN controller that establishment of the tunnel between the MAG and the LMA succeeds. Then the SDN controller forwards a router advertisement message to the mobile node by using the MAG, where the router advertisement message includes an HNP(s) configured by the SDN controller for the mobile node.

In actual application, if the mobile node does not receive the router advertisement message, the mobile node may send a router solicitation (RS) message to the first MAG to request to acquire the HNP(s), and then the first MAG may forward the received RS message to the SDN controller, so that the SDN controller delivers the HNP(s).

After establishment of the tunnel between the MAG and the LMA succeeds and the mobile node receives the router advertisement message to register with a network, the second receiving unit **604** receives packet data from the network, and sends the packet data to the matching unit **605**.

The matching unit **605** matches a destination address prefix included in the packet data with the third matching entry in the second flow entry in the LMA, and if the matching succeeds, sends the packet data to the forwarding unit **606**; or if the matching fails, it indicates that forwarding of the packet data fails. In actual application, if the destination address prefix included in the packet data is the HNP(s) of the mobile node, it indicates that matching with the third matching entry in the second flow entry succeeds.

The forwarding unit **606** forwards the packet data to the MAG through the tunnel between the MAG and the LMA according to the second flow entry, so that the MAG forwards the packet data to the mobile node according to the first flow entry in the MAG Content of the first flow entry includes: a first matching entry: a source address prefix is the HNP(s) of the mobile node; an operation corresponding to the first matching entry: forwarding through a MAG-LMA tunnel interface; a second matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the second matching entry: forwarding to a mobile node interface link.

For example, the content of the second flow entry includes: the third matching entry: the destination address prefix is the HNP(s) of the mobile node; and the operation corresponding to the third matching entry: forwarding through the LMA-MAG tunnel interface. If the destination address prefix included in the packet data received by the second receiving unit **604** is the HNP(s) of the mobile node, it may be determined that matching with the destination address prefix of the third matching entry in the second flow entry succeeds. Then the matching unit **605** may perform the operation corresponding to the third matching entry in the second flow entry, that is, forwarding through the LMA-MAG tunnel interface. In this case, the forwarding unit **606** forwards the packet data to the MAG through the LMA-MAG tunnel interface by using an address of the LMA as a source address and an address of the MAG as a destination address.

Further, in actual application, after receiving the packet data, the MAG may forward the packet data to the mobile node according to the first flow entry in the MAG. In this case, the MAG needs to match the destination address prefix included in the packet data with the second matching entry in the first flow entry, and after the matching succeeds, forward the packet data to the mobile node according to the first flow entry in the MAG. Specifically, if the destination address prefix included in the packet data is the HNP(s) of the mobile node, it indicates that matching with the second matching entry in the first flow entry succeeds.

In this embodiment, an establishment unit **602** establishes a tunnel interface on an LMA side and a tunnel interface on a MAG side according to an establishment message sent by an SDN controller, and an adjustment unit **603** adds a second flow entry of a mobile node according to an adjustment message sent by the SDN controller, so that the MAG and the LMA do not need to negotiate with each other to establish a tunnel. The network element device LMA may perform an operation according to an instruction of the SDN

controller, and therefore a complex control function is simplified, and the network element device LMA is applicable to any IP, thereby reducing costs in network construction. When a network has packet data that needs to be sent to the mobile node, the LMA may forward the packet data to the MAG according to the second flow entry delivered by the SDN controller, so that the MAG sends the packet data to the mobile node according to a first flow entry delivered by the SDN controller, and the LMA and the MAG do not need to negotiate with each other to forward the packet data, which reduces complex signaling interworking performed when the LMA and the MAG forward the packet data, thereby increasing a processing speed of the network element device, and improving network bandwidth utilization.

Referring to FIG. **7**, FIG. **7** shows an embodiment of a network system in the embodiments of the present invention. The network system includes an SDN controller **10**, an MN **11**, a MAG **12**, and an LMA **13**.

The MN **11** is configured to send an L2 attach request message to the MAG **12** when the MN **11** needs to access the MAG **12**, where the L2 attach request message includes an ID of the MN **11**.

The MAG **12** is configured to: add the received L2 attach request message to a bearer message, and forward the bearer message to the SDN controller **10**.

The SDN controller **10** is configured to: send, to each of the MAG **12** and the LMA **13**, a message for establishing a tunnel between the MAG **12** and the LMA **13**, and send, to each of the MAG **12** and the LMA **13**, a message for adjusting a flow entry of the MN **11**.

The MAG **12** is configured to: complete establishment of the tunnel on the MAG **12** side according to the received message for establishing a tunnel between the MAG **12** and the LMA **13**, and adjust, according to the received message for adjusting a flow entry of the MN **11**, a flow entry that is of the MN **11** and stored in the MAG **12**.

The LMA **13** is configured to: complete establishment of the tunnel on the LMA **13** side according to the message for establishing a tunnel between the MAG **12** and the LMA **13**, and adjust, according to the message for adjusting a flow entry of the MN **11**, a flow entry that is of the MN **11** and stored in the LMA **13**.

The SDN controller **10** is further configured to: after establishment of the tunnel between the MAG **12** and the LMA **13** succeeds, configure an HNP(s) for the MN **11**, encapsulate the HNP(s) into a router advertisement message, and send the router advertisement message to the MAG **12**.

The MN **11** is further configured to receive the router advertisement message forwarded by the MAG **12**, to register with a network.

In this embodiment, an MN **11** sends an L2 attach request message to a MAG **12** when the MN **11** needs to access the MAG **12**; the MAG **12** adds the received L2 attach request message to a bearer message, and forwards the bearer message to an SDN controller **10**; and then the SDN controller **10** sends, to each of the MAG **12** and an LMA **13**, a message for establishing a tunnel between the MAG **12** and the LMA **13**, and sends, to each of the MAG **12** and the LMA **13**, a message for adjusting a flow entry of the MN **11**. In this way, the MAG **12** and the LMA **13** may establish the tunnel and adjust the flow entry of the MN **11** according to operation instructions delivered by the SDN controller **10**, so that the network element devices MAG **12** and LMA **13** do not need to negotiate with each other. In addition, in comparison with the prior art, the network element devices LMA **13** and MAG **12** may perform operations according to the instructions of the SDN controller **10**, and therefore complex control functions are simplified, and the network element devices LMA **13** and MAG **12** are applicable to any IP, thereby reducing costs in network construction.

Referring to FIG. **8**, the following describes a process of signaling interworking between network element devices in a network system in an embodiment of the present invention.

801. An MN **11** sends an L2 attach request message to a MAG **12** when the MN **11** needs to access the MAG **12**, where the L2 attach request message includes an ID of the MN **11**.

802. The MAG **12** adds the received L2 attach request message to a bearer message, and forwards the bearer message to an SDN controller **10**.

803. The SDN controller **10** sends a first establishment message and a first adjustment message to the MAG **12**, and sends a second establishment message and a second adjustment message to an LMA **13**.

804. The MAG **12** establishes a tunnel interface on the MAG **12** side according to the received first establishment message, and adds a first flow entry of the MN **11** according to the first adjustment message, where content of the first flow entry includes: a first matching entry: a source address prefix is an HNP(s) of the mobile node; an operation corresponding to the first matching entry: forwarding through a MAG-LMA tunnel interface; a second matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the second matching entry: forwarding to a mobile node interface link.

805. The LMA **13** establishes a tunnel interface on the LMA **13** side according to the received second establishment message, and adds a second flow entry of the MN **11** according to the second adjustment message, where content of the second flow entry includes: a third matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the third matching entry: forwarding through an LMA-MAG tunnel interface.

806. After establishment of a tunnel between the MAG **12** and the LMA **13** succeeds, the SDN controller **10** configures an HNP(s) for the MN **11**, encapsulates the HNP(s) into a router advertisement message, and sends the router advertisement message to the MAG **12**.

807. The MN **11** receives the router advertisement message forwarded by the MAG **12**, to register with a network.

808. The MN **11** sends packet data to the accessed MAG **12** after the MN **11** is registered with the network.

809. The MAG **12** matches a source address prefix included in the received packet data with the first matching entry in the first flow entry in the MAG **12**, and if the matching succeeds, forwards the packet data to the LMA **13** through the tunnel between the MAG **12** and the LMA **13** according to the first flow entry, where a source address of the MN **11** includes the HNP(s).

810. The LMA **13** forwards the received packet data to the network.

811. After the MN **11** is registered with the network, the LMA **13** receives the packet data from the network, matches a destination address prefix included in the packet data with the third matching entry in the second flow entry in the LMA **13**, and if the matching succeeds, forwards the packet data to the MAG **12** through the tunnel between the MAG **12** and the LMA **13** according to the second flow entry.

812. The MAG **12** matches the destination address prefix included in the packet data with the second matching entry in the first flow entry in the MAG **12**, and if the matching succeeds, forwards the packet data to the MN **11** through the tunnel between the MAG **12** and the LMA **13** according to the first flow entry.

It should be noted that there is a parallel relationship between step **807** to step **809** and step **810** to step **812**.

In this embodiment, when an MN **11** needs to register with a network, an SDN controller **10** sends, to network element devices LMA **13** and MAG **12**, a message for establishing a tunnel between the two network element devices and a message for adjusting flow entries that are of the MN **11** and stored in the MAG **12** and the LMA **13**, and the MAG **12** and the LMA **13** may establish the tunnel and adjust the respectively stored flow entry of the MN **11** according to the messages sent by the SDN controller **10**, so that the MAG **12** and the LMA **13** do not need to negotiate with each other when establishing the tunnel. In addition, in comparison with the prior art, the network element devices LMA **13** and MAG **12** may perform operations according to instructions of the SDN controller **10** without complex control functions, and therefore the network element devices LMA **13** and MAG **12** are applicable to any IP, thereby reducing costs in network construction. In addition, the MAG **12** and the LMA **13** need to forward packet data only according to the stored flow entries of the MN **11**, and the LMA **13** and the MAG **12** do not need to negotiate with each other to forward the packet data, which reduces complex signaling interworking performed when the LMA **13** and the MAG **12** forward the packet data, thereby increasing a processing speed of the network element device, and improving network bandwidth utilization.

The following further describes an SDN controller in an embodiment of the present invention. Referring to FIG. **9**, FIG. **9** shows an embodiment of an SDN controller in the embodiments of the present invention. The SDN controller includes:

a processor **901** for processing a message received from each network element, a receiver **902**, and a transmitter **903**.

The receiver **902** is configured to receive a first bearer message that is forwarded by a first MAG in multiple MAGs and that carries a first L2 attach request message, so that a mobile node requests to register with a network, where the first L2 attach request message is sent by the mobile node to the first MAG to request to access the first MAG, and the first L2 attach request message includes an ID of the mobile node.

The transmitter **903** is configured to send, to each of the first MAG and an LMA, a message for establishing a tunnel between the first MAG and the LMA, to establish the tunnel between the first MAG and the LMA.

The transmitter **903** is further configured to send, to each of the first MAG and the LMA, a message for adjusting a flow entry of the mobile node.

The processor **901** is configured to: when establishment of the tunnel between the first MAG and the LMA succeeds, configure an HNP(s) for the mobile node, and encapsulate the HNP(s) into a router advertisement message.

The transmitter **903** is further configured to send the router advertisement message to the first MAG, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the first MAG

In addition, the transmitter **903** is further configured to send a first establishment message to the first MAG, where the first establishment message is used to instruct the first MAG to establish a tunnel interface on the first MAG side, and the first establishment message includes configuration information for establishing the tunnel interface on the first MAG side.

The transmitter **903** is further configured to send a second establishment message to the LMA, where the second establishment message is used to instruct the LMA to establish a tunnel interface on the LMA side, and the second establishment message includes configuration information for establishing the tunnel interface on the LMA side.

The transmitter **903** is further configured to send a first adjustment message to the first MAG, where the first adjustment message is used to instruct the first MAG to add a first flow entry of the mobile node.

The transmitter **903** is further configured to send a second adjustment message to the LMA, where the second adjustment message is used to instruct the LMA to add a second flow entry of the mobile node.

The first flow entry is used to instruct the first MAG to forward data according to content of the first flow entry, and the second flow entry is used to instruct the LMA to forward data according to content of the second flow entry.

The content of the first flow entry includes: a first matching entry: a source address prefix is the HNP(s) of the mobile node; an operation corresponding to the first matching entry: forwarding through a first MAG-LMA tunnel interface; a second matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the second matching entry: forwarding to a mobile node interface link.

The content of the second flow entry includes: a third matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the third matching entry: forwarding through an LMA-first MAG tunnel interface.

The receiver **902** is further configured to: when the mobile node needs to be switched from the first MAG to a second MAG in the multiple MAGs, receive a second bearer message that is forwarded by the second MAG and that carries a second L2 attach request message, so that the mobile node requests to register with the network, where the second L2 attach request message is sent by the mobile node to the second MAG to request to access the second MAG, and the second L2 attach request message includes the ID of the mobile node.

The transmitter **903** is further configured to send, to each of the second MAG and the LMA, a message for establishing a tunnel between the second MAG and the LMA, to establish the tunnel between the second MAG and the LMA.

The transmitter **903** is further configured to send, to each of the second MAG and the LMA, the message for adjusting a flow entry of the mobile node.

The processor **901** is further configured to: when establishment of the tunnel between the second MAG and the LMA succeeds, configure the HNP(s) for the mobile node, and encapsulate the HNP(s) into the router advertisement message.

The transmitter **903** is further configured to send the router advertisement message to the second MAG when establishment of the tunnel between the second MAG and the LMA succeeds, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the second MAG, where the router advertisement message includes the HNP(s) configured by the SDN controller for the mobile node.

The transmitter **903** is further configured to send a third establishment message to the second MAG, where the third establishment message is used to instruct the second MAG to establish a tunnel interface on the second MAG side, and

the third establishment message includes configuration information for establishing the tunnel interface on the second MAG side.

The transmitter **903** is further configured to send a fourth establishment message to the LMA, where the fourth establishment message is used to instruct the LMA to establish a tunnel interface on the LMA side, and the fourth establishment message includes configuration information for establishing the tunnel interface on the LMA side.

The transmitter **903** is further configured to send a third adjustment message to the second MAG, where the third adjustment message is used to instruct the second MAG to add a third flow entry of the mobile node.

The transmitter **903** is further configured to send a fourth adjustment message to the LMA, where the fourth adjustment message is used to instruct the LMA to add a fourth flow entry of the mobile node.

The third flow entry is used to instruct the second MAG to forward data according to content of the third flow entry.

The fourth flow entry is used to instruct the LMA to forward data according to content of the fourth flow entry.

The content of the third flow entry includes: a fourth matching entry: a source address prefix is the HNP(s) of the mobile node; an operation corresponding to the fourth matching entry: forwarding through a second MAG-LMA tunnel interface; a fifth matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the fifth matching entry: forwarding to the mobile node interface link.

The content of the fourth flow entry includes: a sixth matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the sixth matching entry: forwarding through an LMA-second MAG tunnel interface.

In this embodiment, a receiver **902** receives a first bearer message that is forwarded by a first MAG in multiple MAGs and that carries a first L2 attach request message, to request a mobile node to register with a network; a transmitter **903** sends, to each of the first MAG and an LMA, a message for establishing a tunnel between the first MAG and the LMA, to establish the tunnel between the first MAG and the LMA, and sends, to each of the first MAG and the LMA, a message for adjusting a flow entry of the mobile node; a processor **901** configures an HNP(s) for the mobile node, and encapsulates the HNP(s) into a router advertisement message; and then the transmitter **903** sends the router advertisement message to the first MAG. In this way, an SDN controller instructs the LMA and the first MAG to establish the tunnel, and sends a flow entry of the mobile node to each of the first MAG and the LMA, so that the LMA and the MAG do not need to negotiate with each other. In addition, in comparison with the prior art, the network element devices LMA and MAG may perform operations according to instructions of the SDN controller, and therefore complex control functions are simplified, and the network element devices LMA and MAG are applicable to any IP, thereby reducing costs in network construction.

The following further describes a MAG in an embodiment of the present invention. Referring to FIG. **10**, FIG. **10** shows an embodiment of a MAG in the embodiments of the present invention. The MAG includes:

a processor **1001**, a transmitter **1002**, and a receiver **1003**.

The receiver **1003** is configured to receive an L2 attach request message sent by a mobile node, where the L2 attach request message includes an ID of the mobile node.

The transmitter **1002** is configured to: add the L2 attach request message to a bearer message, and forward the bearer message to a software defined networking SDN controller.

The receiver **1003** is further configured to receive a message that is sent by the SDN controller and for establishing a tunnel between the MAG and a local mobility anchor LMA.

The processor **1001** is configured to complete establishment of the tunnel on the MAG side according to the message for establishing a tunnel between the MAG and the LMA.

The receiver **1003** is further configured to receive a message that is sent by the SDN controller and for adjusting a flow entry of the mobile node.

The processor **1001** is further configured to adjust, according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the MAG

The transmitter **1002** is further configured to: when establishment of the tunnel between the MAG and the LMA succeeds, forward a router advertisement message received from the SDN controller to the mobile node, so that the mobile node is registered with a network, where the router advertisement message includes an HNP(s) configured by the SDN controller for the mobile node.

In addition, the receiver **1003** is further configured to receive an establishment message and an adjustment message that are sent by the SDN controller.

The processor **1001** is further configured to: establish a tunnel interface on the MAG side according to the establishment message, and add a first flow entry of the mobile node according to the adjustment message.

Content of the first flow entry includes: a first matching entry: a source address prefix is the HNP(s) of the mobile node; an operation corresponding to the first matching entry: forwarding through a MAG-LMA tunnel interface; a second matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the second matching entry: forwarding to a mobile node interface link.

The receiver **1003** is further configured to: after the mobile node is registered with the network, receive packet data sent by the mobile node.

The processor **1001** is further configured to match a source address prefix included in the packet data with the first matching entry in the first flow entry in the MAG

The transmitter **1002** is further configured to: when the matching succeeds, forward the packet data to the LMA through the tunnel between the MAG and the LMA according to the first flow entry, so that the LMA forwards the packet data to the network.

In this embodiment, a transmitter **1002** adds an L2 attach request message to a bearer message, and forwards the bearer message to an SDN controller, and then a processor **1001** establishes a tunnel on a MAG side and adjusts a flow entry of a mobile node according to a message for establishing a tunnel and a message for adjusting a flow entry of the mobile node that are sent by the SDN controller, so that the MAG does not need to negotiate with an LMA to establish the tunnel. In addition, in comparison with the prior art, the network element device MAG may perform an operation according to an instruction of the SDN controller, and therefore a complex control function is simplified, and the network element device MAG is applicable to any IP, thereby reducing costs in network construction.

The following further describes an LMA in an embodiment of the present invention. Referring to FIG. **11**, FIG. **11**

shows an embodiment of an LMA in the embodiments of the present invention. The LMA includes:

a processor **1101** and a receiver **1102**.

The receiver **1102** is configured to: after an SDN controller receives a bearer message sent by a MAG, receive a message that is sent by the SDN controller and for establishing a tunnel between the MAG and the LMA, where the bearer message carries an L2 attach request message, the L2 attach request message is sent by a mobile node to the MAG to request to access the MAG, and the L2 attach request message includes an ID of the mobile node.

The processor **1101** is configured to complete establishment of the tunnel on the LMA side according to the message for establishing a tunnel between the MAG and the LMA.

The receiver **1102** is further configured to receive a message that is sent by the SDN controller and for adjusting a flow entry of the mobile node.

The processor **1101** is further configured to adjust, according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the LMA.

In addition, the receiver **1102** is further configured to receive an establishment message and an adjustment message that are sent by the SDN controller.

The processor **1101** is further configured to: establish a tunnel interface on the LMA side according to the establishment message, and add a second flow entry of the mobile node according to the adjustment message.

Content of the second flow entry includes: a third matching entry: a destination address prefix is an HNP(s) of the mobile node; and an operation corresponding to the third matching entry: forwarding through an LMA-MAG tunnel interface.

The receiver **1102** is further configured to receive packet data from a network after establishment of the tunnel between the MAG and the LMA succeeds and the mobile node receives a router advertisement message to register with the network.

The processor **1101** is further configured to: match a destination address prefix included in the packet data with the third matching entry in the second flow entry in the LMA, and when the matching unit successfully performs the matching, forward the packet data to the MAG through the tunnel between the MAG and the LMA according to the second flow entry, so that the MAG forwards the packet data to the mobile node according to a first flow entry in the MAG

Content of the first flow entry includes: a first matching entry: a source address prefix is the HNP(s) of the mobile node; an operation corresponding to the first matching entry: forwarding through a MAG-LMA tunnel interface; a second matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the second matching entry: forwarding to a mobile node interface link.

In this embodiment, a processor **1101** completes establishment of a tunnel on an LMA side according to a message that is sent by an SDN controller and for establishing a tunnel between a MAG and the LMA, and adjusts, according to a message that is sent by the SDN controller and for adjusting a flow entry of a mobile node, a flow entry that is of the mobile node and stored in the LMA, so that the MAG and the LMA do not need to negotiate with each other to establish the tunnel. The network element device LMA may perform an operation according to an instruction of the SDN controller, and therefore a complex control function is simplified, and the network element device LMA is applicable to any IP, thereby reducing costs in network construction.

The following describes a binding registration method performed by the foregoing SDN controller. Referring to FIG. **12**, an embodiment of a binding registration method in the embodiments of the present invention includes the following steps:

1201. An SDN controller receives a first bearer message that is forwarded by a first MAG in multiple MAGs and that carries a first L2 attach request message, so that a mobile node requests to register with a network.

In this embodiment, the first L2 attach request message is sent by the mobile node to the first MAG to request to access the first MAG, and the first L2 attach request message includes an ID of the mobile node. In actual application, the mobile node determines, according to a requirement, to access the first MAG in the multiple MAGs, and in this case, the first MAG receives the first L2 attach request message. Because there is no matched flow entry in the first MAG, the first MAG sends the SDN controller the first bearer message that carries the first L2 attach request message.

1202. The SDN controller sends, to each of the first MAG and an LMA, a message for establishing a tunnel between the first MAG and the LMA, to establish the tunnel between the first MAG and the LMA.

1203. The SDN controller sends, to each of the first MAG and the LMA, a message for adjusting a flow entry of the mobile node.

In this embodiment, after step **1201** is performed, the SDN controller sends, to each of the first MAG and the LMA, the message for establishing a tunnel between the first MAG and the LMA. At the same time, the SDN controller may further send, to each of the first MAG and the LMA, the message for adjusting a flow entry of the mobile node. In actual application, the message for establishing a tunnel between the first MAG and the LMA may include configuration information for establishing the tunnel, and tunnels of different types have different configuration information. The message of the flow entry of the mobile node is a flow entry related to the mobile node, and the message for adjusting a flow entry of the mobile node is used to adjust flow entries of the mobile node in the first MAG and the LMA.

1204. The SDN controller configures an HNP(s) for the mobile node, encapsulates the HNP(s) into a router advertisement message, and sends the router advertisement message to the first MAG

In this embodiment, when establishment of the tunnel between the first MAG and the LMA succeeds, the SDN controller configures the HNP(s) for the mobile node. In actual application, when the first MAG and the LMA each complete establishment of the tunnel and adjustment of the flow entries of the mobile node, it indicates that establishment of the tunnel between the first MAG and the LMA succeeds. In this case, the SDN controller may separately receive responses fed back by the first MAG and the LMA, so that the SDN controller is notified that establishment of the tunnel succeeds. Then the SDN controller encapsulates the HNP(s) into the router advertisement message, and sends the router advertisement message to the first MAG, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the first MAG In actual application, when the mobile node receives the router advertisement message from the first MAG, it indicates that the mobile node is registered with the network.

It should be noted that step **1202** to step **1204** are not limited to a sequence in this embodiment. In actual application, the sequence of performing operations in step **1202** to step **1204** by the SDN controller is not limited. The SDN controller may first perform step **1204** and then perform step **1202** and step **1203**, or the SDN controller may simultaneously perform step **1202** and step **1203** and then perform step **1204**.

In this embodiment, an SDN controller receives a first bearer message that is forwarded by a first MAG in multiple MAGs and that carries a first L2 attach request message, to request a mobile node to register with a network; the SDN controller sends, to each of the first MAG and an LMA, a message for establishing a tunnel between the first MAG and the LMA, to establish the tunnel between the first MAG and the LMA; the SDN controller sends, to each of the first MAG and the LMA, a message for adjusting a flow entry of the mobile node; and the SDN controller configures an HNP(s) for the mobile node, encapsulates the HNP(s) into a router advertisement message, and sends the router advertisement message to the first MAG. In this way, the SDN controller instructs the network element devices LMA and first MAG to establish the tunnel, and sends a flow entry of the mobile node to each of the first MAG and the LMA, so that the network element devices do not need to negotiate with each other. In addition, in comparison with the prior art, the network element devices LMA and MAG may perform operations according to instructions of the SDN controller, and therefore complex control functions are simplified, and the network element devices LMA and MAG are applicable to any IP, thereby reducing costs in network construction.

The following uses a specific instance to describe a binding registration method in an embodiment of the present invention. Referring to FIG. **13**, another embodiment of a binding registration method in the embodiments of the present invention includes the following steps:

1301. An SDN controller receives a first bearer message that is forwarded by a first MAG in multiple MAGs and that carries a first L2 attach request message, so that a mobile node requests to register with a network.

In this embodiment, the first L2 attach request message is sent by the mobile node to the first MAG to request to access the first MAG, and the first L2 attach request message includes an ID of the mobile node. In actual application, the mobile node determines, according to a requirement, to access the first MAG in the multiple MAGs, and in this case, the first MAG receives the first L2 attach request message. Because there is no matched flow entry in the first MAG, the first MAG sends the SDN controller the first bearer message that carries the first L2 attach request message.

In an actual application scenario, the L2 attach request message may be carried in a packet in form in this embodiment.

1302. The SDN controller sends a first establishment message to the first MAG

1303. The SDN controller sends a second establishment message to an LMA.

In this embodiment, the first establishment message is used to instruct the first MAG to establish a tunnel interface on the first MAG side, and the second establishment message is used to instruct the LMA to establish a tunnel interface on the LMA side. In actual application, the first establishment message includes configuration information for establishing the tunnel interface on the first MAG side, the second establishment message includes configuration information for establishing the tunnel interface on the LMA side, and tunnels of different types have different configuration information.

In an actual application scenario, establishment of an IP-in-IP tunnel is used as an example for description. In this case, the first establishment message and the second establishment message mainly include information in which an address Proxy-CoA **1** on the first MAG side and an address LMAA on the LMA side are encapsulated, where Proxy-CoA **1** is an address of the first MAG, and LMAA is an address of the LMA.

1304. The SDN controller sends a first adjustment message to the first MAG

1305. The SDN controller sends a second adjustment message to the LMA.

In this embodiment, the first adjustment message is used to instruct the first MAG to add a first flow entry of the mobile node, and the second adjustment message is used to instruct the LMA to add a second flow entry of the mobile node. The first flow entry is used to instruct the first MAG to forward data according to content of the first flow entry, and the second flow entry is used to instruct the LMA to forward data according to content of the second flow entry. The content of the first flow entry includes: a first matching entry: a source address prefix is an HNP(s) of the mobile node; an operation corresponding to the first matching entry: forwarding through a first MAG-LMA tunnel interface; a second matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the second matching entry: forwarding to a mobile node interface link. The content of the second flow entry includes: a third matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the third matching entry: forwarding through an LMA-first MAG tunnel interface.

1306. The SDN controller configures an HNP(s) for the mobile node, encapsulates the HNP(s) into a router advertisement message, and sends the router advertisement message to the first MAG

In this embodiment, if establishment of the tunnel between the first MAG and the LMA succeeds, the SDN controller configures the HNP(s) for the mobile node. In actual application, when the first MAG and the LMA each complete establishment of the tunnel and adjustment of the flow entries of the mobile node, it indicates that establishment of the tunnel between the first MAG and the LMA succeeds. In this case, the SDN controller may separately receive responses fed back by the first MAG and the LMA, so that the SDN controller is notified that establishment of the tunnel succeeds. Then the SDN controller encapsulates the HNP(s) into the router advertisement message, and sends the router advertisement message to the first MAG, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the first MAG In actual application, when the mobile node receives the router advertisement message from the first MAG, it indicates that the mobile node is registered with the network.

In actual application, if the mobile node does not receive the router advertisement message, the mobile node may send an RS message to the first MAG to request to acquire the HNP(s), and then the first MAG may forward the received RS message to the SDN controller, so that the SDN controller delivers the HNP(s).

1307. When the mobile node needs to be switched from the first MAG to a second MAG in the multiple MAGs, the SDN controller receives a second bearer message that is

forwarded by the second MAG and that carries a second L2 attach request message, to request the mobile node to register with the network.

In this embodiment, the second L2 attach request message is sent by the mobile node to the second MAG to request to access the second MAG, and the second L2 attach request message includes the ID of the mobile node. In actual application, the mobile node may be switched to the second MAG in the multiple MAGs, and in this case, the second MAG receives the second L2 attach request message. Because there is no matched flow entry in the second MAG, the second MAG sends the SDN controller the second bearer message that carries the second L2 attach request message.

In an actual application scenario, the L2 attach request message may be carried in a packet in form in this embodiment.

1308. The SDN controller sends, to each of the second MAG and the LMA, a message for establishing a tunnel between the second MAG and the LMA, to establish the tunnel between the second MAG and the LMA.

In this embodiment, the message for establishing a tunnel between the second MAG and the LMA may include configuration information for establishing the tunnel, and tunnels of different types have different configuration information.

Specifically, the SDN controller sends a third establishment message to the second MAG, where the third establishment message is used to instruct the second MAG to establish a tunnel interface on the second MAG side, and the third establishment message includes configuration information for establishing the tunnel interface on the second MAG side.

The SDN controller sends a fourth establishment message to the LMA, where the fourth establishment message is used to instruct the LMA to establish a tunnel interface on the LMA side, and the fourth establishment message includes configuration information for establishing the tunnel interface on the LMA side.

In an actual application scenario, establishment of an IP-in-IP tunnel is used as an example for description. In this case, the third establishment message and the fourth establishment message mainly include information in which an address Proxy-CoA **2** on the second MAG side and the address LMAA on the LMA side are encapsulated, where Proxy-CoA **2** is an address of the second MAG, and LMAA is the address of the LMA.

In actual application, the original tunnel between the first MAG and the LMA is changed to the tunnel between the second MAG and the LMA. In this case, the SDN controller may send a tunnel teardown instruction to each of the first MAG and the LMA, to tear down the tunnel between the first MAG and the LMA.

1309. The SDN controller sends, to each of the second MAG and the LMA, the message for adjusting a flow entry of the mobile node.

In this embodiment, the SDN controller sends, to each of the second MAG and the LMA, the message for adjusting a flow entry of the mobile node. In actual application, the message of the flow entry of the mobile node is a flow entry related to the mobile node, and the message for adjusting a flow entry of the mobile node is used to adjust flow entries of the mobile node in the first MAG and the LMA. Specifically, the SDN controller sends a third adjustment message to the second MAG, where the third adjustment message is used to instruct the second MAG to add a third flow entry of the mobile node. Content of the third flow entry includes: a fourth matching entry: a source address prefix is the HNP(s) of the mobile node; an operation corresponding to the fourth matching entry: forwarding through a second MAG-LMA tunnel interface; a fifth matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the fifth matching entry: forwarding to the mobile node interface link. The SDN controller sends a fourth adjustment message to the LMA, where the fourth adjustment message is used to instruct the LMA to add a fourth flow entry of the mobile node. The third flow entry is used to instruct the second MAG to forward data according to the content of the third flow entry, and the fourth flow entry is used to instruct the LMA to forward data according to content of the fourth flow entry. The content of the fourth flow entry includes: a sixth matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the sixth matching entry: forwarding through an LMA-second MAG tunnel interface.

1310. If establishment of the tunnel between the second MAG and the LMA succeeds, the SDN controller configures the HNP(s) for the mobile node, encapsulates the HNP(s) into the router advertisement message, and sends the router advertisement message to the second MAG, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the second MAG.

In this embodiment, if establishment of the tunnel between the second MAG and the LMA succeeds, the SDN controller configures the HNP(s) for the mobile node. In actual application, when the second MAG and the LMA each complete establishment of the tunnel and adjustment of the flow entries of the mobile node, it indicates that establishment of the tunnel between the second MAG and the LMA succeeds. In this case, the SDN controller may separately receive responses fed back by the second MAG and the LMA, so that the SDN controller is notified that establishment of the tunnel succeeds; and encapsulate the HNP(s) into the router advertisement message, and send the router advertisement message to the second MAG, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the second MAG

In this embodiment, an SDN controller instructs network element devices LMA and first MAG to establish a tunnel, and sends a flow entry of a mobile node to each of the first MAG and the LMA, so that the network element devices do not need to perform complex tunnel parameter negotiation with each other. In addition, in comparison with the prior art, the network element devices LMA and MAG may perform operations according to instructions of the SDN controller without complex control functions, and therefore the network element devices LMA and MAG are applicable to any IP, thereby reducing costs in network construction. When the mobile node needs to be switched from the first MAG to a second MAG, the SDN controller may further instruct the network element devices LMA and second MAG to establish a tunnel, and send a flow entry of the mobile node to each of the second MAG and the LMA, and therefore the LMA and a different MAG do not need to perform a frequent and complex signaling interworking process when the mobile node moves and is switched to the different MAG, thereby increasing a processing speed of the network element device, and improving network bandwidth utilization.

The following describes a data forwarding method performed by the foregoing MAG Referring to FIG. **14**, an embodiment of a data forwarding method in the embodiments of the present invention includes the following steps:

1401. A MAG receives an L2 attach request message sent by a mobile node.

In this embodiment, the L2 attach request message includes an ID of the mobile node. In actual application, the mobile node sends the L2 attach request message to the MAG so as to access the MAG

1402. The MAG adds the L2 attach request message to a bearer message, and forwards the bearer message to an SDN controller.

In this embodiment, because there is no matched flow entry when the MAG receives the L2 attach request message, the MAG may add the L2 attach request message to the bearer message, and forward the bearer message to the SDN controller.

1403. The MAG receives a message that is sent by the SDN controller and for establishing a tunnel between the MAG and an LMA, and completes establishment of the tunnel on the MAG side according to the message for establishing a tunnel between the MAG and the LMA.

In this embodiment, after step **1402** is performed, the MAG may receive the message that is sent by the SDN controller and for establishing a tunnel between the MAG and the LMA, and then after receiving the message for establishing a tunnel between the MAG and the LMA, the MAG completes establishment of the tunnel on the MAG side according to the message for establishing a tunnel between the MAG and the LMA. In actual application, the SDN controller simultaneously sends the LMA the message for establishing a tunnel between the LMA and the MAG, and the LMA may complete establishment of the tunnel on the LMA side according to the message for establishing a tunnel between the LMA and the MAG

In actual application, the message for establishing a tunnel between the MAG and the LMA may include configuration information for establishing the tunnel, and tunnels of different types have different configuration information.

1404. The MAG receives a message that is sent by the SDN controller and for adjusting a flow entry of the mobile node, and adjusts, according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the MAG

In this embodiment, at the same time of performing step **1403**, the MAG may further receive the message that is sent by the SDN controller and for adjusting a flow entry of the mobile node, and then the MAG may adjust, according to the message for adjusting a flow entry of the mobile node, the flow entry that is of the mobile node and stored in the MAG. In actual application, the message of the flow entry of the mobile node is a flow entry related to the mobile node. The SDN controller may also send the LMA the message for adjusting a flow entry of the mobile node, so that the LMA adjusts, according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the LMA.

1405. If establishment of the tunnel between the MAG and the LMA succeeds, the MAG forwards a router advertisement message received from the SDN controller to the mobile node, so that the mobile node is registered with a network.

In this embodiment, the router advertisement message includes an HNP(s) configured by the SDN controller for the mobile node. In actual application, after the MAG completes operations in step **1403** and step **1404**, the MAG may feed back a response to the SDN controller. Certainly, after the LMA completes establishment of the tunnel on the LMA side and adjustment of the flow entry that is of the mobile node and stored in the LMA, the LMA may also feed back a response to the SDN controller, to notify the SDN controller that establishment of the tunnel between the MAG and the LMA succeeds. Then the MAG may receive the router advertisement message sent by the SDN controller, and forward the router advertisement message received from the SDN controller to the mobile node, so that the mobile node is registered with the network.

In this embodiment, a MAG is responsible for adding an L2 attach request message to a bearer message, and forwarding the bearer message to an SDN controller, and then the MAG completes establishment of a tunnel on the MAG side according to a message that is sent by the SDN controller and for establishing a tunnel between the MAG and an LMA, and adjusts, according to a message that is sent by the SDN controller and for adjusting a flow entry of an mobile node, a flow entry that is of the mobile node and stored in the MAG, so that the MAG and the LMA do not need to negotiate with each other to establish the tunnel. In addition, in comparison with the prior art, the network element device MAG may perform an operation according to an instruction of the SDN controller, and therefore a complex control function is simplified, and the network element device MAG is applicable to any IP, thereby reducing costs in network construction.

The following uses a specific instance to describe a data forwarding method in an embodiment of the present invention. Referring to FIG. **15**, another embodiment of a data forwarding method in the embodiments of the present invention includes the following steps:

1501. A MAG receives an L2 attach request message sent by a mobile node.

In this embodiment, the L2 attach request message includes an ID of the mobile node. In actual application, the mobile node sends the L2 attach request message to the MAG so as to access the MAG

1502. The MAG adds the L2 attach request message to a bearer message, and forwards the bearer message to an SDN controller.

In this embodiment, because there is no matched flow entry when the MAG receives the L2 attach request message, the MAG may add the L2 attach request message to the bearer message, and forward the bearer message to the SDN controller.

1503. The MAG receives a message that is sent by the SDN controller and for establishing a tunnel between the MAG and an LMA, and establishes a tunnel interface on the MAG side according to the message for establishing a tunnel between the MAG and the LMA.

In this embodiment, the MAG receives the message that is sent by the SDN controller and for establishing a tunnel between the MAG and the LMA, and establishes the tunnel interface on the MAG side according to the message for establishing a tunnel between the MAG and the LMA. In actual application, the message for establishing a tunnel between the MAG and the LMA includes configuration information for establishing the tunnel interface on the MAG side, and tunnels of different types have different configuration information.

Certainly, in actual application, the network element device LMA may also receive another message that is sent by the SDN controller and for establishing a tunnel between the MAG and the LMA, and the LMA establishes a tunnel interface on the LMA side according to the another message for establishing a tunnel between the MAG and the LMA, where the another message for establishing a tunnel between

the MAG and the LMA includes configuration information for establishing the tunnel interface on the LMA side.

1504. The MAG receives a message that is sent by the SDN controller and for adjusting a flow entry of the mobile node, and adds a first flow entry of the mobile node according to the message for adjusting a flow entry of the mobile node.

In this embodiment, content of the first flow entry includes: a first matching entry: a source address prefix is an HNP(s) of the mobile node; an operation corresponding to the first matching entry: forwarding through a MAG-LMA tunnel interface; a second matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the second matching entry: forwarding to a mobile node interface link. In actual application, the MAG may forward data according to the first flow entry.

In actual application, the network element device LMA may also receive another message that is sent by the SDN controller and for adjusting a flow entry of the mobile node, and the LMA may add a second flow entry according to the another message for adjusting a flow entry of the mobile node. Content of the second flow entry includes: a third matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the third matching entry: forwarding through an LMA-MAG tunnel interface.

1505. If establishment of the tunnel between the MAG and the LMA succeeds, the MAG forwards a router advertisement message received from the SDN controller to the mobile node, so that the mobile node is registered with a network.

In this embodiment, the router advertisement message includes an HNP(s) configured by the SDN controller for the mobile node. In actual application, after the MAG completes operations in step **1503** and step **1504**, the MAG may feed back a response to the SDN controller. Certainly, after the LMA completes establishment of the tunnel interface on the LMA side and adjustment of a flow entry that is of the mobile node and stored in the LMA, the LMA may also feed back a response to the SDN controller, to notify the SDN controller that establishment of the tunnel between the MAG and the LMA succeeds. Then the MAG may receive the router advertisement message sent by the SDN controller, and forward the router advertisement message received from the SDN controller to the mobile node, so that the mobile node is registered with the network.

In actual application, if the mobile node does not receive the router advertisement message, the mobile node may send an RS message to the first MAG to request to acquire the HNP(s), and then the first MAG may forward the received RS message to the SDN controller, so that the SDN controller delivers the HNP(s).

1506. After the mobile node is registered with the network, the MAG receives packet data sent by the mobile node, matches a source address prefix included in the packet data with a first matching entry in the first flow entry in the MAG, and if the matching succeeds, performs step **1507**; or if the matching fails, it indicates that forwarding of the packet data fails.

1507. The MAG forwards the packet data to the LMA through the tunnel between the MAG and the LMA according to the first flow entry, so that the LMA forwards the packet data to the network.

In this embodiment, after the mobile node is registered with the network, the mobile node needs to send the packet data to the network. In this case, the MAG may receive the packet data sent by the mobile node, and match the source address prefix included in the packet data with the first matching entry in the first flow entry in the MAG The MAG forwards the packet data to the LMA through the tunnel between the MAG and the LMA according to the first flow entry. For example, content of the first flow entry in step **1504** includes: a first matching entry: a source address prefix is an HNP(s) of the mobile node; an operation corresponding to the first matching entry: forwarding through a MAG-LMA tunnel interface; a second matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the second matching entry: forwarding to a mobile node interface link. If the source address prefix included in the packet data received by the MAG is the HNP(s) of the mobile node, the MAG may determine that matching with the source address prefix of the first matching entry in the first flow entry succeeds, and then the MAG may perform the operation corresponding to the first matching entry in the first flow entry, that is, forwarding through the MAG-LMA tunnel interface. In this case, the MAG needs to forward the packet data to the LMA through the MAG-LMA tunnel by using an address of the MAG as a source address and an address of the LMA as a destination address.

In actual application, the LMA forwards the packet data to the network without a flow entry of the mobile node, and the LMA needs to forward the packet data to the network according to another flow entry. How to forward the packet data to the network according to the another flow entry is the prior art, and no further details are provided herein.

In this embodiment, a MAG is responsible for adding an L2 attach request message to a bearer message, and forwarding the bearer message to an SDN controller, and then the MAG establishes a tunnel on the MAG side according to a message that is sent by the SDN controller and for establishing a tunnel between the MAG and an LMA, and adds a first flow entry of a mobile node according to a message that is sent by the SDN controller and for adjusting a flow entry of the mobile node, so that the MAG and the LMA do not need to negotiate with each other. In addition, in comparison with the prior art, the network element device MAG may perform an operation according to an instruction of the SDN controller without a complex control function, and therefore the network element device MAG is applicable to any IP, thereby reducing costs in network construction. When the mobile node has packet data that needs to be sent to a network, the MAG may forward the packet data to the LMA according to the first flow entry delivered by the SDN controller, so that the LMA forwards the packet data to the network, and the LMA and the MAG do not need to negotiate with each other to forward the packet data, which reduces complex signaling interworking performed when the LMA and the MAG forward the packet data, thereby increasing a processing speed of the network element device, and improving network bandwidth utilization.

The following describes a data forwarding method performed by the foregoing LMA. Referring to FIG. **16**, an embodiment of a data forwarding method in the embodiments of the present invention includes the following steps:

1601. After an SDN controller receives a bearer message sent by a MAG, an LMA receives a message that is sent by the SDN controller and for establishing a tunnel between the MAG and the LMA, and completes establishment of the tunnel on the LMA side according to the message for establishing a tunnel between the MAG and the LMA.

In this embodiment, the bearer message carries an L2 attach request message, the L2 attach request message is sent

by a mobile node to the MAG to request to access the MAG, and the L2 attach request message includes an ID of the mobile node. In actual application, the MAG may also receive another message that is sent by the SDN controller and for establishing a tunnel between the MAG and the LMA, and complete establishment of the tunnel on the MAG side according to the another message for establishing a tunnel between the MAG and the LMA.

In actual application, the message for establishing a tunnel between the MAG and the LMA may include configuration information for establishing the tunnel, and tunnels of different types have different configuration information.

1602. The LMA receives a message that is sent by the SDN controller and for adjusting a flow entry of a mobile node, and adjusts, according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the LMA.

In this embodiment, at the same time of performing step **1601**, the LMA receives the message that is sent by the SDN controller and for adjusting a flow entry of the mobile node. In actual application, the message of the flow entry of the mobile node is a flow entry related to the mobile node, and the SDN controller may also send the MAG the message for adjusting a flow entry of the mobile node, so that the MAG adjusts, according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the MAG

Further, after the LMA completes operations in step **1601** and step **1602**, the LMA may feed back a response to the SDN controller. Certainly, after the MAG completes establishment of the tunnel on the MAG side and adjustment of the flow entry that is of the mobile node and stored in the MAG, the MAG may also feed back a response to the SDN controller, to notify the SDN controller that establishment of the tunnel between the MAG and the LMA succeeds, and then the SDN controller forwards a router advertisement message to the mobile node by using the MAG. After the mobile node receives the router advertisement message, it indicates that the mobile node is registered with the network, where the router advertisement message includes an HNP(s) configured by the SDN controller for the mobile node.

In this embodiment, an LMA completes establishment of a tunnel on the LMA side according to a message that is sent by an SDN controller and for establishing a tunnel between a MAG and the LMA, and adjusts, according to a message that is sent by the SDN controller and for adjusting a flow entry of a mobile node, a flow entry that is of the mobile node and stored in the LMA, so that the MAG and the LMA do not need to negotiate with each other to establish the tunnel. The network element device LMA may perform an operation according to an instruction of the SDN controller, and therefore a complex control function is simplified, and the network element device LMA is applicable to any IP, thereby reducing costs in network construction.

The following uses a specific instance to describe a data forwarding method in an embodiment of the present invention. Referring to FIG. **17**, another embodiment of a data forwarding method in the embodiments of the present invention includes the following steps:

1701. After an SDN controller receives a bearer message sent by a MAG, an LMA receives a message that is sent by the SDN controller and for establishing a tunnel between the MAG and the LMA, and establishes a tunnel interface on the LMA side according to the message for establishing a tunnel between the MAG and the LMA.

In this embodiment, the bearer message carries an L2 attach request message, the L2 attach request message is sent by a mobile node to the MAG to request to access the MAG, and the L2 attach request message includes an ID of the mobile node. In actual application, the message for establishing a tunnel between the MAG and the LMA includes configuration information for establishing the tunnel interface on the LMA side, and tunnels of different types have different configuration information.

In actual application, the network element device MAG may also receive another message that is sent by the SDN controller and for establishing a tunnel between the MAG and the LMA, and complete establishment of a tunnel interface on the MAG side according to the another message for establishing a tunnel between the MAG and the LMA, where the another message for establishing a tunnel between the MAG and the LMA includes configuration information for establishing the tunnel interface on the MAG side.

1702. The LMA receives a message that is sent by the SDN controller and for adjusting a flow entry of the mobile node, and adds a second flow entry of the mobile node according to the message for adjusting a flow entry of the mobile node.

In this embodiment, content of the second flow entry includes: a third matching entry: a destination address prefix is an HNP(s) of the mobile node; and an operation corresponding to the third matching entry: forwarding through an LMA-MAG tunnel interface. In actual application, the LMA may forward data according to the second flow entry, and the network element device MAG may also add a first flow entry according to an instruction of the SDN controller.

Further, after the LMA completes operations in step **1701** and step **1702**, the LMA may feed back a response to the SDN controller. Certainly, after the MAG completes establishment of the tunnel interface on the MAG side and adding of the first flow entry, the MAG may also feed back a response to the SDN controller, to notify the SDN controller that establishment of the tunnel between the MAG and the LMA succeeds. Then the SDN controller forwards a router advertisement message to the mobile node by using the MAG, where the router advertisement message includes an HNP(s) configured by the SDN controller for the mobile node.

In actual application, if the mobile node does not receive the router advertisement message, the mobile node may send an RS message to the first MAG to request to acquire the HNP(s), and then the first MAG may forward the received RS message to the SDN controller, so that the SDN controller delivers the HNP(s).

1703. The LMA receives packet data from a network after establishment of the tunnel between the MAG and the LMA succeeds and the mobile node receives a router advertisement message to register with the network.

In this embodiment, after the mobile node is registered with the network, the LMA may receive the packet data from the network.

1704. The LMA matches a destination address prefix included in the packet data with a third matching entry in the second flow entry in the LMA, and if the matching succeeds, performs step **1705**; or if the matching fails, it indicates that forwarding of the packet data fails.

1705. The LMA forwards the packet data to the MAG through the tunnel between the MAG and the LMA according to the second flow entry, so that the MAG forwards the packet data to the mobile node according to a first flow entry in the MAG

In this embodiment, content of the first flow entry includes: a first matching entry: a source address prefix is the HNP(s) of the mobile node; an operation corresponding to the first matching entry: forwarding through a MAG-LMA tunnel interface; a second matching entry: a destination address prefix is the HNP(s) of the mobile node; and an operation corresponding to the second matching entry: forwarding to a mobile node interface link. The LMA forwards the packet data to the MAG through the tunnel between the MAG and the LMA according to the second flow entry, so that the MAG forwards the packet data to the mobile node according to the first flow entry in the MAG. For example, content of the second flow entry in step **1702** includes: a third matching entry: a destination address prefix is an HNP(s) of the mobile node; and an operation corresponding to the third matching entry: forwarding through an LMA-MAG tunnel interface. If the destination address prefix included in the packet data received by the LMA is the HNP(s) of the mobile node, the LMA may determine that matching with the destination address prefix of the third matching entry in the second flow entry succeeds, and then the LMA may perform the operation corresponding to the third matching entry in the second flow entry, that is, forwarding through the LMA-MAG tunnel interface. In this case, the LMA forwards the packet data to the MAG through the LMA-MAG tunnel by using an address of the LMA as a source address and an address of the MAG as a destination address.

Further, in actual application, after receiving the packet data, the MAG may forward the packet data to the mobile node according to the first flow entry in the MAG. In this case, the MAG needs to match the second matching entry in the first flow entry according to the destination address prefix included in the packet data, and after the matching succeeds, forward the packet data to the mobile node according to the first flow entry in the MAG Specifically, if the destination address prefix included in the packet data is the HNP(s) of the mobile node, it indicates that matching with the second matching entry in the first flow entry succeeds.

In this embodiment, an LMA establishes a tunnel interface on the LMA side according to a message that is sent by an SDN controller and for establishing a tunnel between a MAG and the LMA, and adds a second flow entry of a mobile node according to a message that is sent by the SDN controller and for adjusting a flow entry of the mobile node, so that the MAG and the LMA do not need to negotiate with each other to establish the tunnel. The network element device LMA may perform an operation according to an instruction of the SDN controller without a complex control function, and therefore the network element device LMA is applicable to any IP, thereby reducing costs in network construction. When a network has packet data that needs to be sent to the mobile node, the LMA may forward the packet data to the MAG according to the second flow entry delivered by the SDN controller, so that the MAG sends the packet data to the mobile node according to a first flow entry delivered by the SDN controller, and the LMA and the MAG do not need to negotiate with each other to forward the packet data, which reduces complex signaling interworking performed when the LMA and the MAG forward the packet data, thereby increasing a processing speed of the network element device, and improving network bandwidth utilization.

In addition, it should be noted that in the embodiments provided in this application, understandably the disclosed system, apparatus, and method may be implemented in other manners. For example, the foregoing described apparatus embodiment is merely exemplary. For example, the unit division is merely logical function division and may be other division in actual implementation. For example, multiple units or components may be combined or integrated into another system, or some features may be ignored or not performed. In addition, the displayed or discussed mutual couplings or direct couplings or communication connections may be implemented through some interfaces. The indirect couplings or communication connections between the apparatuses or units may be implemented in electronic, mechanical, or other forms.

The units described as separate parts may be or may not be physically separate, and parts displayed as units may be or may not be physical units, may be located in one position, or may be distributed on multiple network units. Some or all of the units may be selected according to actual requirements to achieve the objectives of the solutions of the embodiments.

In addition, functional units in the embodiments of the present invention may be integrated into one processing unit, or each of the units may exist alone physically, or two or more units may be integrated into one unit. The foregoing integrated unit may be implemented in a form of hardware, or may be implemented in a form of a software functional unit.

When the integrated unit is implemented in the form of a software functional unit and sold or used as an independent product, the integrated unit may be stored in a computer-readable storage medium. Based on such an understanding, the technical solutions of the present invention essentially, or the part contributing to the prior art, or all or some of the technical solutions may be implemented in a form of a software product. The computer software product is stored in a storage medium and includes several instructions for instructing a computer device (which may be a personal computer, a server, a network device, or the like) to perform all or some of the steps of the methods in the embodiments of the present invention. The foregoing storage medium includes: any medium that can store program code, such as a universal serial bus (USB) flash drive, a removable hard disk, a read-only memory (ROM), a random access memory (RAM), a magnetic disk, or an optical disc.

The foregoing embodiments are merely intended for describing the technical solutions of the present invention, but not for limiting the present invention. Although the present invention is described in detail with reference to the foregoing embodiments, persons of ordinary skill in the art should understand that they may still make modifications to the technical solutions described in the foregoing embodiments or make equivalent replacements to some technical features thereof, without departing from the spirit and scope of the technical solutions of the embodiments of the present invention. Additionally, statements made herein characterizing the invention refer to an embodiment of the invention and not necessarily all embodiments.

What is claimed is:

1. A software defined networking (SDN) controller, wherein the SDN controller comprises:

a processor, configured for processing a message received from a network element;

a receiver, configured to receive a first bearer message that is forwarded by a first mobile access gateway (MAG) of multiple MAGs and that carries a first L2 attach request message, so that a mobile node requests to register with a network, wherein the first L2 attach request message is sent by the mobile node to the first

MAG to request to access the first MAG, and the first L2 attach request message comprises an ID of the mobile node; and

a transmitter, configured to send, to each of the first MAG and a local mobility anchor (LMA), a message for establishing a tunnel between the first MAG and the LMA, and to send, to each of the first MAG and the LMA, a message for adjusting a flow entry of the mobile node;

wherein the processor is further configured to, when establishment of the tunnel between the first MAG and the LMA succeeds, configure home network prefix(es) (HNP(s)) for the mobile node, and encapsulate the HNP(s) into a router advertisement message; and

wherein the transmitter is further configured to send the router advertisement message to the first MAG, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the first MAG.

2. The SDN controller according to claim **1**, wherein the transmitter is further configured to send a first establishment message to the first MAG, wherein the first establishment message is configured to instruct the first MAG to establish a tunnel interface on the first MAG side, and the first establishment message comprises configuration information for establishing the tunnel interface on the first MAG side;

wherein the transmitter is further configured to send a second establishment message to the LMA, wherein the second establishment message is configured to instruct the LMA to establish a tunnel interface on the LMA side, and the second establishment message comprises configuration information for establishing the tunnel interface on the LMA side;

wherein the transmitter is further configured to send a first adjustment message to the first MAG, wherein the first adjustment message is configured to instruct the first MAG to add a first flow entry of the mobile node; and

wherein the transmitter is further configured to send a second adjustment message to the LMA, wherein the second adjustment message is configured to instruct the LMA to add a second flow entry of the mobile node.

3. The SDN controller according to claim **2**, wherein the first flow entry is configured to instruct the first MAG to forward data according to content of the first flow entry; and

wherein the second flow entry is configured to instruct the LMA to forward data according to content of the second flow entry.

4. The SDN controller according to claim **3**, wherein the content of the first flow entry comprises: a first matching entry indicating that a source address prefix is the HNP(s) of the mobile node, wherein an operation corresponding to the first matching entry includes forwarding data through a first MAG-LMA tunnel interface; and a second matching entry indicating that a destination address prefix is the HNP(s) of the mobile node, wherein an operation corresponding to the second matching entry includes forwarding data to a mobile node interface link; and

wherein the content of the second flow entry comprises: a third matching entry indicating that a destination address prefix is the HNP(s) of the mobile node, wherein an operation corresponding to the third matching entry includes forwarding data through an LMA-first MAG tunnel interface.

5. The SDN controller according to claim **1**, wherein the receiver is further configured to, when the mobile node needs to be switched from the first MAG to a second MAG of the multiple MAGs, receive a second bearer message that is forwarded by the second MAG and that carries a second L2 attach request message, so that the mobile node requests to register with the network, wherein the second L2 attach request message is sent by the mobile node to the second MAG to request to access the second MAG, and the second L2 attach request message comprises the ID of the mobile node;

wherein the transmitter is further configured to send, to each of the second MAG and the LMA, a message for establishing a tunnel between the second MAG and the LMA, to establish the tunnel between the second MAG and the LMA;

wherein the transmitter is further configured to send, to each of the second MAG and the LMA, the message for adjusting a flow entry of the mobile node;

wherein the processor is further configured to, when establishment of the tunnel between the second MAG and the LMA succeeds, configure the HNP(s) for the mobile node, and encapsulate the HNP(s) into the router advertisement message; and

wherein the transmitter is further configured to send the router advertisement message to the second MAG when establishment of the tunnel between the second MAG and the LMA succeeds, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the second MAG, wherein the router advertisement message comprises the HNP(s) configured by the SDN controller for the mobile node.

6. The SDN controller according to claim **5**, wherein the transmitter is configured to send a third establishment message to the second MAG, wherein the third establishment message is configured to instruct the second MAG to establish a tunnel interface on the second MAG side, and the third establishment message comprises configuration information for establishing the tunnel interface on the second MAG side;

wherein the transmitter is further configured to send a fourth establishment message to the LMA, wherein the fourth establishment message is configured to instruct the LMA to establish a tunnel interface on the LMA side, and the fourth establishment message comprises configuration information for establishing the tunnel interface on the LMA side;

wherein the transmitter is configured to send a third adjustment message to the second MAG, wherein the third adjustment message is configured to instruct the second MAG to add a third flow entry of the mobile node; and

wherein the transmitter is configured to send a fourth adjustment message to the LMA, wherein the fourth adjustment message is configured to instruct the LMA to add a fourth flow entry of the mobile node.

7. The SDN controller according to claim **6**, wherein the third flow entry is configured to instruct the second MAG to forward data according to content of the third flow entry; and

wherein the fourth flow entry is configured to instruct the LMA to forward data according to content of the fourth flow entry.

8. The SDN controller according to claim **7**, wherein the content of the third flow entry comprises: a fourth matching entry indicating that a source address prefix is the HNP(s) of the mobile node, wherein an operation corresponding to the fourth matching entry includes forwarding data through a second MAG-LMA tunnel interface; and a fifth matching entry indicating that a destination address prefix is the HNP(s) of the mobile node, wherein an operation corre-

sponding to the fifth matching entry includes forwarding data to a mobile node interface link; and

wherein the content of the fourth flow entry comprises: a sixth matching entry indicating that a destination address prefix is the HNP(s) of the mobile node, wherein an operation corresponding to the sixth matching entry includes forwarding data through an LMA-second MAG tunnel interface.

9. A network system, comprising:

a software defined networking (SDN) controller;

a mobile node;

a mobile access gateway (MAG); and

a local mobility anchor (LMA);

wherein the mobile node is configured to send an L2 attach request message to the MAG when the mobile node needs to access the MAG, wherein the L2 attach request message comprises an ID of the mobile node;

wherein the MAG is configured to: add the received L2 attach request message to a bearer message, and forward the bearer message to the SDN controller;

wherein the SDN controller is configured to: send, to each of the MAG and the LMA, a message for establishing a tunnel between the MAG and the LMA, and send, to each of the MAG and the LMA, a message for adjusting a flow entry of the mobile node;

wherein the MAG is further configured to: complete establishment of the tunnel on the MAG side according to the received message for establishing a tunnel between the MAG and the LMA, and adjust, according to the received message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the MAG;

wherein the LMA is configured to: complete establishment of the tunnel on the LMA side according to the message for establishing a tunnel between the MAG and the LMA, and adjust, according to the message for adjusting a flow entry of the mobile node, a flow entry that is of the mobile node and stored in the LMA;

wherein the SDN controller is further configured to: after establishment of the tunnel between the MAG and the LMA succeeds, configure home network prefix(es) (HNP(s)) for the mobile node, encapsulate the HNP(s) into a router advertisement message, and send the router advertisement message to the MAG; and

wherein the mobile node is further configured to receive the router advertisement message forwarded by the MAG, to register with a network.

10. The system according to claim **9**, wherein the SDN controller is further configured to: send a first establishment message and a first adjustment message to the MAG, and send a second establishment message and a second adjustment message to the LMA;

wherein the MAG is configured to: establish a tunnel interface on the MAG side according to the received first establishment message, and add a first flow entry of the mobile node according to the first adjustment message; and

wherein the LMA is configured to: establish a tunnel interface on the LMA side according to the received second establishment message, and add a second flow entry of the mobile node according to the second adjustment message.

11. The system according to claim **10**, wherein content of the first flow entry comprises: a first matching entry indicating that a source address prefix is the HNP(s) of the mobile node, wherein an operation corresponding to the first matching entry includes forwarding data through a MAG-LMA tunnel interface; and a second matching entry indicating that a destination address prefix is the HNP(s) of the mobile node, wherein an operation corresponding to the second matching entry includes forwarding data to a mobile node interface link; and

wherein content of the second flow entry comprises: a third matching entry indicating that a destination address prefix is the HNP(s) of the mobile node, wherein an operation corresponding to the third matching entry includes forwarding data through an LMA-MAG tunnel interface.

12. The system according to claim **11**, wherein the mobile node is further configured to send packet data to the MAG after the mobile node is registered with the network;

wherein the MAG is further configured to: match a source address prefix comprised in the received packet data with the first matching entry in the first flow entry in the MAG, and if the matching succeeds, forward the packet data to the LMA through the tunnel between the MAG and the LMA according to the first flow entry; and

wherein the LMA is further configured to forward the received packet data to the network.

13. The system according to claim **11**, wherein the LMA is further configured to: after the mobile node is registered with the network, receive packet data from the network, match a destination address prefix comprised in the packet data with the third matching entry in the second flow entry in the LMA, and if the matching succeeds, forward the packet data to the MAG through the tunnel between the MAG and the LMA according to the second flow entry; and

wherein the MAG is further configured to: match the destination address prefix comprised in the packet data with the second matching entry in the first flow entry in the MAG, and if the matching succeeds, forward the packet data to the mobile node through the tunnel between the MAG and the LMA according to the first flow entry.

14. A binding registration method, wherein the method comprises:

receiving, by a software defined networking (SDN) controller, a first bearer message that is forwarded by a first mobile access gateway (MAG) of multiple MAGs and that carries a first L2 attach request message, to request a mobile node to register with a network, wherein the first L2 attach request message is sent by the mobile node to the first MAG to request to access the first MAG, and the first L2 attach request message comprises an ID of the mobile node;

sending, by the SDN controller, to each of the first MAG and a local mobility anchor (LMA), a message for establishing a tunnel between the first MAG and the LMA;

sending, by the SDN controller to each of the first MAG and the LMA, a message for adjusting a flow entry of the mobile node; and

in response to successful establishment of the tunnel between the first MAG and the LMA, configuring, by the SDN controller, home network prefix(es) (HNP(s)) for the mobile node, encapsulating the HNP(s) into a router advertisement message, and sending the router advertisement message to the first MAG, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the first MAG.

15. The method according to claim **14**, wherein sending the message for establishing the tunnel between the first MAG and the LMA further comprises:

sending, by the SDN controller, a first establishment message to the first MAG, wherein the first establishment message is used to instruct the first MAG to establish a tunnel interface on the first MAG side, and the first establishment message comprises configuration information for establishing the tunnel interface on the first MAG side; and

sending, by the SDN controller, a second establishment message to the LMA, wherein the second establishment message is used to instruct the LMA to establish a tunnel interface on the LMA side, and the second establishment message comprises configuration information for establishing the tunnel interface on the LMA side; and

wherein sending the message for adjusting the flow entry of the mobile node further comprises:

sending, by the SDN controller, a first adjustment message to the first MAG, wherein the first adjustment message is used to instruct the first MAG to add a first flow entry of the mobile node; and

sending, by the SDN controller, a second adjustment message to the LMA, wherein the second adjustment message is used to instruct the LMA to add a second flow entry of the mobile node.

16. The method according to claim **15**, wherein the first flow entry is used to instruct the first MAG to forward data according to content of the first flow entry; and

wherein the second flow entry is used to instruct the LMA to forward data according to content of the second flow entry.

17. The method according to claim **16**, wherein the content of the first flow entry comprises: a first matching entry indicating that a source address prefix is the HNP(s) of the mobile node, wherein an operation corresponding to the first matching entry includes forwarding data through a first MAG-LMA tunnel interface; and a second matching entry indicating that a destination address prefix is the HNP(s) of the mobile node, wherein an operation corresponding to the second matching entry includes forwarding data to a mobile node interface link; and

wherein the content of the second flow entry comprises: a third matching entry indicating that a destination address prefix is the HNP(s) of the mobile node, wherein an operation corresponding to the third matching entry includes forwarding data through an LMA-first MAG tunnel interface.

18. The method according to claim **14**, wherein the method further comprises:

when the mobile node needs to be switched from the first MAG to a second MAG of the multiple MAGs, receiving, by the SDN controller, a second bearer message that is forwarded by the second MAG and that carries a second L2 attach request message, to request the mobile node to register with the network, wherein the second L2 attach request message is sent by the mobile node to the second MAG to request to access the second MAG, and the second L2 attach request message comprises the ID of the mobile node;

sending, by the SDN controller to each of the second MAG and the LMA, a message for establishing a tunnel between the second MAG and the LMA, to establish the tunnel between the second MAG and the LMA;

sending, by the SDN controller to each of the second MAG and the LMA, the message for adjusting a flow entry of the mobile node; and

in response to successful establishment of the tunnel between the second MAG and the LMA, configuring, by the SDN controller, the HNP(s) for the mobile node, encapsulating the HNP(s) into the router advertisement message, and sending the router advertisement message to the second MAG, so that the mobile node is registered with the network when the mobile node receives the router advertisement message from the second MAG.

19. The method according to claim **18**, wherein sending the message for establishing the tunnel between the second MAG and the LMA further comprises:

sending, by the SDN controller, a third establishment message to the second MAG, wherein the third establishment message is used to instruct the second MAG to establish a tunnel interface on the second MAG side, and the third establishment message comprises configuration information for establishing the tunnel interface on the second MAG side; and

sending, by the SDN controller, a fourth establishment message to the LMA, wherein the fourth establishment message is used to instruct the LMA to establish a tunnel interface on the LMA side, and the fourth establishment message comprises configuration information for establishing the tunnel interface on the LMA side; and

wherein sending the message for adjusting the flow entry of the mobile node further comprises:

sending, by the SDN controller, a third adjustment message to the second MAG, wherein the third adjustment message is used to instruct the second MAG to add a third flow entry of the mobile node; and

sending, by the SDN controller, a fourth adjustment message to the LMA, wherein the fourth adjustment message is used to instruct the LMA to add a fourth flow entry of the mobile node.

20. The method according to claim **19**, wherein the third flow entry is used to instruct the second MAG to forward data according to content of the third flow entry; and

wherein the fourth flow entry is used to instruct the LMA to forward data according to content of the fourth flow entry.

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