



- (51) **International Patent Classification:**
H04L 29/06 (2006.01)
- (21) **International Application Number:**
PCT/CN2015/100064
- (22) **International Filing Date:**
31 December 2015 (31.12.2015)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
201410854404.7 31 December 2014 (31.12.2014) CN
- (71) **Applicant:** HANGZHOU H3C TECHNOLOGIES CO., LTD. [CN/CN]; 466 Changhe Road, Binjiang District, Hangzhou, Zhejiang 310052 (CN).
- (72) **Inventors:** SONG, Yuan; Room 730, Oriental Electronic BLD., NO.2, Chuangye Road, Shangdi Information Industry Base, Haidian District, Beijing 100085 (CN). FU, Jiajia; Room 730, Oriental Electronic BLD., NO.2, Chuangye Road, Shangdi Information Industry Base, Haidian District, Beijing 100085 (CN).
- (74) **Agent:** DEQI INTELLECTUAL PROPERTY LAW CORPORATION; 7/F, Xueyuan International Tower, NO.1 Zhichun Road, Haidian District, Beijing 100083 (CN).

- (81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) **Title:** ACCESSING EXTERNAL NETWORK FROM VIRTUAL NETWORK

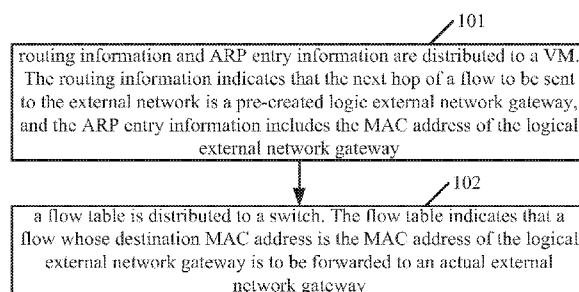


FIG. 1

(57) **Abstract:** A controller distributes routing information and Address Resolution Protocol (ARP) entry information to a Virtual Machine (VM). The routing information indicates that a next hop of a flow to be sent to the external network is a pre-created logical external network gateway, and the ARP entry information comprises a Media Access Control (MAC) address of the logical external network gateway. The controller distributes a flow table to a switch. The flow table indicates that a flow whose destination MAC address is the MAC address of the logical external network gateway is to be forwarded to an actual external network gateway.



ACCESSING EXTERNAL NETWORK FROM VIRTUAL NETWORK

Background

[0001] Software defined networks (SDN) such as OpenFlow networks enable a fine-grained flow forwarding capability for layer 2 and layer 3 switches. A SDN, such as an OpenFlow, may extend forwarding modes of the layer 2 switch and the layer 3 switch, so that the layer 2 switch and the layer 3 switch can not only perform forwarding based on a Media Access Control (MAC) address and forwarding based on an Internet Protocol (IP) address, but can also perform flow forwarding based on packet header description. Through the SDN, a control plane can be separated from a forwarding device, and decisions of all forwarding actions can be migrated from a switch to a SDN controller.

Brief Description of the Drawings

[0002] Features of the present disclosure are illustrated by way of example and not limited in the following figure(s), in which like numerals indicate like elements, in which:

[0003] FIG. 1 is a flowchart illustrating a method for accessing an external network from a virtual network according to an example of the present disclosure.

[0004] FIG. 2 is a diagram illustrating a process of creating a logical external network gateway when accessing an external network from a virtual network according to an example of the present disclosure.

[0005] FIG. 3 is a diagram illustrating a process of distributing a routing table and an Address Resolution Protocol (ARP) entry when accessing an external network from a virtual network according to an example of the present disclosure.

[0006] FIG. 4 is a diagram illustrating a process of distributing a static flow table when accessing an external network from a virtual network according to an example of the present disclosure.

[0007] FIG. 5 is a diagram illustrating a process of forwarding a flow accessing an external network when accessing the external network from a virtual network according to an example of the present disclosure.

[0008] FIG. 6 is a diagram illustrating the structure of an apparatus for accessing an external network from a virtual network according to an example of the present disclosure.

5 [0009] FIG. 7 is a diagram illustrating the hardware structure of a controller according to an example of the present disclosure.

[0010] FIG. 8 is a diagram illustrating the structure of a flow routing apparatus according to an example of the present disclosure.

[0011] FIG. 9 is a diagram illustrating the hardware structure of a Virtual Machine (VM) according to an example of the present disclosure.

10 [0012] FIG. 10 is a diagram illustrating the structure of a flow forwarding apparatus according to an example of the present disclosure.

[0013] FIG. 11 is a diagram illustrating the hardware structure of a switch according to an example of the present disclosure.

Detailed Description

15 [0014] For simplicity and illustrative purposes, the present disclosure is described by referring mainly to an example thereof. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present disclosure. It will be readily apparent however, that the present disclosure may be practiced without limitation to these specific details. In other instances, some methods
20 and structures have not been described in detail so as not to unnecessarily obscure the present disclosure. Throughout the present disclosure, the terms “a” and “an” are intended to denote at least one of a particular element. As used herein, the term “includes” means includes but not limited to, the term “including” means including but not limited to. The term “based on” means based at least in part on.

25 [0015] A software defined network (SDN), such as an OpenFlow network, includes a controller and a switch. The controller distributes a flow table to the switch, and the switch checks and forwards a packet according to the flow table.

[0016] Each flow entry in the flow table includes a header field, an active counter and zero, one or more actions.

30 [0017] The switch checks each packet according to the flow table. If the header field of a packet matches the header field of a flow entry in the flow table, the switch

processes the packet according to the flow entry. If the header field of the packet does not match any flow entry in the flow table, the switch forwards the packet to the controller via a safe channel, and then the controller decides an action for the packet.

[0018] A virtual machine (VM) is a virtual computer that is hosted on a physical computing device. A physical computing device, such as a server, may be virtualized into a plurality of virtual machines each of which acts as an independent server.

[0019] The SDN network may be applied to a virtual network to forward flows. In some examples of the present disclosure, a virtual network is a computer network that consists, at least in part, of virtual network links. A virtual network link is a link that does not consist of a physical (wired or wireless) connection between two computing devices but is implemented using methods of network virtualization. In this case, the network virtualization is based on vSwitch technology. The virtual network may be virtual switch inside a physical device which connects VMs hosted in the physical device, or may be a distributed virtual switch which spans several physical devices and connects VMs in the several physical devices.

[0020] In order for a device in a virtual network to access an external network such as a physical network or another virtual network, an external network gateway may be set between the virtual network and the external network. In some examples of the present disclosure, the external network gateway is a border gateway, which is the boundary of internal network (i.e. the virtual network) and external network (such as the Internet). The external network gateway connects the virtual network to the external network, so as to implement connection between the virtual network and the external network. When a device in the virtual network is to access a server in the external network, a flow is forwarded to the external network gateway first and then the flow is forwarded by the external network gateway into the external network.

[0021] In various examples of the present disclosure, the virtual network may be an Overlay network. In the Overlay network, in default routing of each virtual machine (VM), the next hop of the VM is a VM gateway. A source VM determines whether the destination IP address of a packet and the IP address of the source VM belong to the same network segment. If the destination IP address of the packet and the IP address of the source VM belong to the same network segment, the source VM sends the packet to the destination IP address. If the destination IP address of the packet and the IP address of the source VM do not belong to the same network segment, the source VM sets the

destination MAC address of the packet as the MAC address of the VM gateway in the default routing, and sets the destination IP address of the packet as the IP address of an accessed object.

[0022] When a VM is to access an external network from a virtual network, a destination IP address to be accessed by the VM is an IP address of the external network, and thus the IP address of the VM and the IP address of the external network do not belong to the same network segment. Accordingly, the VM sets the destination MAC address of a packet as the MAC address of a VM gateway in default routing, and sets the destination IP address of the packet as the IP address of an accessed object. Afterwards, the VM sends the packet to a switch, and the switch performs flow entry matching for the packet. If the packet matches a flow entry, the switch forwards the packet according to the flow entry. If the packet does not match any flow entry, the switch sends the packet to a controller via a safe channel, and then the controller may process the packet. Accordingly, the switch sends to the controller an initial packet of a flow not matching any flow entry, and then the controller selects routing for the flow. When finding that the flow is to access the external network from the virtual network, the controller distributes a flow table to the switch. The flow table may indicate the switch to forward the flow to be sent to the destination IP address to a gateway of the external network. After the flow table is distributed, the switch may perform flow entry matching for the flow to be sent to the destination IP address, and then forwards the flow to the gateway of the external network. Afterwards, the gateway of the external network forwards the flow to the external network.

[0023] Referring to FIG. 2, the IP address of a VM is 2.2.2.20, and the next hop of the VM in default routing is a gateway whose IP address is 2.2.2.1. If the VM whose IP address is 2.2.2.20 is to access a server in a physical network, where the IP address of the server is 1.1.1.1, a method for accessing the physical network from the virtual network is implemented as follows.

[0024] The VM recognizes that the IP address 1.1.1.1 of the server and the IP address of the VM do not belong to the same network segment. The VM sets the destination MAC address of a packet as the MAC address of the next hop of the VM in the default routing and sets the destination IP address of the packet as the IP address of an accessed object. In this example, the VM sets the destination MAC address of the packet as the MAC address of the gateway whose IP address is 2.2.2.1., and sets the destination

IP address of the packet as the IP address 1.1.1.1 of the server. Afterwards, the VM sends the packet to the switch. The switch checks the flow table distributed by the controller, finds that there is no flow entry matching the IP address 1.1.1.1, and thus sends the packet to the controller via a safe channel. Afterwards, the controller processes the packet.

5 [0025] The controller distributes the flow table to the switch, and the flow table indicates that the packet whose destination IP address is 1.1.1.1 is to be sent to a gateway A of the external network.

[0026] If the VM is to send another packet to the IP address 1.1.1.1, the switch forwards the packet to the gateway A of the external network because the switch has the
10 flow entry matching the IP address 1.1.1.1.

[0027] In a virtual network in which flows are forwarded based on a Software Defined Network (SDN), when the above mentioned method for accessing the external network from the virtual network is adopted, initial packets of all flows accessing the external network are sent to the controller. When a large number of flows access the
15 external network, the controller will become a bottleneck. Since the flow table in the switch is configured based on a destination IP address, when there are a large number of accessed nodes in the external network, the controller will distribute a large number of flow tables to the switch, which causes a low flow table matching efficiency and affects the performance of the switch.

20 [0028] Examples of the present disclosure provide a method and apparatus for accessing an external network from a virtual network. By the method and the apparatus, the controller will not become a bottleneck, thereby improving system performance.

[0029] FIG. 1 is a flowchart illustrating a method for accessing an external network from a virtual network according to an example of the present disclosure. The method
25 may be applied to a controller. As shown in FIG. 1, the method includes following blocks.

[0030] At block 101, routing information and ARP entry information are distributed to a VM. The routing information indicates that the next hop of a flow to be sent to the external network is a pre-created logical external network gateway, and the ARP entry information includes the MAC address of the logical external network gateway.
30 Pre-created means that the gateway is configured in advance, at a time prior to sending the routing and ARP information. For instance the logical external network gateway may be configured by the controller. In some examples of the present disclosure, the logical external network gateway is a fake gateway address which is used to identify the flow to

make it match the flow table and be redirected to an actual external network gateway. The actual external network gateway is a real physical border gateway which forwards flows between the internal network and the external network actually.

[0031] At block 102, a flow table is distributed to a switch. The flow table indicates that a flow whose destination MAC address is the MAC address of the logical external network gateway is to be forwarded to an actual external network gateway.

[0032] In an example of the present disclosure, the method further includes pre-creating the logical external network gateway for a network segment that is in the virtual network and is to interwork with the external network.

[0033] In an example of the present disclosure, since the VM has the routing information for indicating that the flow to be sent to the external network is to be sent to the logical external network gateway, the VM can attach a tag on the flow according to the routing information. Since the switch has a flow table for indicating the forwarding of the flow attached with the tag, the switch forwards the flow attached with the tag to the actual external network gateway according to the flow table after recognizing the flow attached with the tag. Accordingly, it is unnecessary to send to the controller the initial packet of the flow to be sent to the external network, thereby avoiding that the controller becomes the bottleneck and improving system performance.

[0034] In various examples of the present disclosure, the flow table in the switch is configured based on the MAC address of the logical external network gateway, and the logical external network gateway is created based on a network segment instead of a single IP address. Accordingly, for each logical external network gateway, it is unnecessary to distribute a flow table for each IP address of the external network, but necessary to distribute one flow table to the switch. In this case, the number of distributed flow tables may be reduced, a flow table matching efficiency may be increased and system performance may be improved.

[0035] The controller creates one logical external network gateway for each network segment that is in the virtual network and is to interwork with the external network, so as to conveniently perform IP address matching for each network segment and manage each logical external network gateway.

[0036] After creating the logical external network gateway, the controller distributes the routing information and the ARP entry information to the VM. The routing information indicates that the next hop of the flow to be sent to the external network is the

logical external network gateway. The ARP entry information includes the MAC address of the logical external network gateway.

[0037] If there are multiple network segments that are to interwork with the external network in the virtual network and one logical external network gateway has been created for each network segment, the routing information distributed to the VM indicates that the next hop of the flow to be sent to the external network is a logical external network gateway corresponding to the network segment to which the VM belongs. For example, VM1-VM3 belong to a network segment 1, VM4-VM6 belong to a network segment 2, a logical external network gateway 1 is created for the network segment 1 and a logical external network gateway 2 is created for the network segment 2. Accordingly, routing information distributed to VM1-VM3 indicates that the next hop of the flow to be sent to the external network is the logical external network gateway 1, and routing information distributed to VM4-VM6 indicates that the next hop of the flow to be sent to the external network is the logical external network gateway 2.

[0038] The VM processes the flow according to the routing information and the ARP entry information. When the destination IP address of the flow and the IP address of the VM do not belong to the same network segment, the VM determines whether the destination IP address of the flow is an internal address of the virtual network or an address of the external network. If the destination IP address of the flow is the address of the external network, the VM sets the destination MAC address of the flow as the MAC address of the next hop of the VM in the default routing, i.e., the MAC address of the logical external network gateway. If the destination IP address of the flow is the internal address of the virtual network, the VM sets the destination MAC address of the flow as the MAC address of the next hop in internal routing of the virtual network.

[0039] The MAC address of the logical external network gateway may be set as a pre-configured MAC address, for example, a pre-configured special character. The controller distributes a flow table. The flow table indicates the switch to modify the destination MAC address of a flow whose destination MAC address is the MAC address of the logical external network gateway to the MAC address of an actual external network gateway corresponding to the logical external network gateway, and the switch forwards the flow to the actual external network gateway.

[0040] After the MAC address of the logical external network gateway is set as the pre-configured MAC address, it is convenient to manage each logical external network

gateway.

[0041] In an example of the present disclosure, MAC addresses of multiple logical external network gateways corresponding to the same actual external network gateway may be set as the same MAC address, and MAC addresses of multiple logical external network gateways corresponding to different actual external network gateways may be set as different MAC addresses, so as to manage each logical external network gateway conveniently. Since the MAC addresses of multiple logical external network gateways corresponding to the same actual external network gateway are the same, for the multiple logical external network gateways, the controller distributes one flow table to the switch.

The flow table may indicate the switch to modify the destination MAC address of a flow whose destination MAC address is the MAC address of the multiple logical external network gateways to the MAC address of the actual external network gateway corresponding to the multiple logical external network gateways. Afterwards, the switch forwards the flow to the actual external network gateway. In this case, the number of distributed flow tables may be reduced, and the flow table matching efficiency may be improved.

[0042] For example, suppose the logical external network gateway 1 and the logical external network gateway 2 correspond to the actual external network gateway 1, and a logical external network gateway 3 and a logical external network gateway 4 correspond to the actual external network gateway 2. Accordingly, the MAC addresses of the logical external network gateway 1 and the logical external network gateway 2 may be set as one value, for example, set as BB, and the MAC addresses of the logical external network gateway 3 and the logical external network gateway 4 may be set as another value, for example, set as EE. A MAC address usually has 6 bytes or 8 bytes, and is represented with hex. For convenience of description, the MAC addresses are represented with BB and EE. The controller distributes a flow table 1 to the switch for the logical external network gateway 1 and the logical external network gateway 2, and the flow table indicates the switch to modify the destination MAC address of a flow whose destination MAC address is BB to the MAC address of the actual external network gateway 1. The controller distributes a flow table 2 to the switch for the logical external network gateway 3 and the logical external network gateway 4, and the flow table indicates the switch to modify the destination MAC address of a flow whose destination MAC address is EE to the MAC address of the actual external network gateway 2.

[0043] In another example, the MAC address of each logical external network gateway may be set as the MAC address of an actual external network gateway corresponding to the logical external network gateway. In this case, after receiving a flow whose destination MAC address is the MAC address of the logical external network gateway, the switch does not modify the destination MAC address of the flow but forwards the flow to the actual external network gateway corresponding to the logical external network gateway. If the flow table distributed to the switch by the controller does not contain an action of modifying the destination MAC address, the switch does not modify the destination MAC address when forwarding the flow according to the flow table.

[0044] Referring to FIGs. 2-5, a method for accessing an external network from a virtual network is described according to examples of the present disclosure.

[0045] Referring to FIG. 2, a logical external network gateway is created on a controller of a distributed switch, and a MAC address is allocated to the logical external network gateway.

[0046] Referring to FIG. 3, the controller distributes a routing table and an ARP entry to a VM, and the routing table indicates that a flow to be sent to a network segment of the external network is to be forwarded to the logical external network gateway.

[0047] Referring to FIG. 4, the controller distributes a static flow table to the switch, and the static flow table indicates that the flow to be sent to the logical external network gateway is to be forwarded to an actual external network gateway. In a conventional Overlay network, the flow table is generated after an initial packet is sent to the controller, and thus is called a dynamic flow table. In the example of the present disclosure, the static flow table is distributed according to configuration (for example, a network segment in the virtual network) without needing flow triggering, and have been generated before a flow is generated.

[0048] Referring to FIG. 5, after the VM has the routing table for indicating that the flow to be sent to the network segment of the external network is to be sent to the logical external network gateway, and the switch has the static flow table for indicating that the flow to be sent to the logical external network gateway is to be forwarded to the actual external network gateway, the VM modifies the destination MAC address of the flow to be sent to the network segment of the external network to the MAC address of the logical external network gateway according to the routing table, and then sends to the switch the

flow to be sent to the network segment of the external network. The switch forwards the flow to be sent to the network segment of the external network to the actual external network gateway according to the static flow table.

[0049] FIG. 2 is a diagram illustrating a process of creating a logical external network gateway when accessing an external network from a virtual network according to an example of the present disclosure.

[0050] As shown in FIG. 2, a logical external network gateway is created on a controller. For example, a logical external network gateway whose IP address is 2.2.2.2 is created in FIG. 2. The controller may set one logical external network gateway for each network segment that is to interwork with an external network.

[0051] The controller may set the MAC address of the logical external network gateway as a predefined value. MAC addresses of multiple logical external network gateways corresponding to the same actual external network gateway may be set as the same MAC address, for example, set as BB. For example, "BB" in FIG. 2 represents the MAC address of the logical external network gateways.

[0052] After the MAC address of the logical external network gateway is set as the predefined value, the logical external network gateway may be managed conveniently.

[0053] The controller may set the MAC address of the logical external network gateway as the MAC address of the actual external network gateway corresponding to the logical external network gateway. For example, in FIG. 2, the MAC address of the logical external network gateway is set as the MAC address of an actual external network gateway A.

[0054] FIG. 3 is a diagram illustrating a process of distributing a routing table and an ARP entry when accessing an external network from a virtual network according to an example of the present disclosure.

[0055] In FIG. 3, the controller distributes the routing table and the ARP entry to the VM. The routing table indicates that the next hop of the VM in default routing is the logical external network gateway and the next hop of the VM in the internal routing of the virtual network is an original gateway of the VM. The MAC address of the logical external network gateway in the ARP entry is BB.

[0056] Referring to FIG. 3, after the controller distributes the routing table and the ARP entry to the VM whose IP address is 2.2.2.20, the next hop of the VM in the default routing is changed to the logical external network gateway 2.2.2.2 from the original

gateway 2.2.2.1, and the next hop of the VM in the internal routing of the virtual network is still the original gateway 2.2.2.1.

[0057] In an example, the controller may interwork with a configuration module that is in the VM and can receive the routing table and the ARP entry. For example, the configuration module of the VM may be VM tools for monitoring the state and process of the VM and configuring the IP address of the VM. The controller may interwork with the VM tools to distribute the routing table and the ARP entry to the VM tools.

[0058] FIG. 4 is a diagram illustrating a process of distributing a static flow table when accessing an external network from a virtual network according to an example of the present disclosure.

[0059] The controller distributes a static flow table to a vSwitch corresponding to a VM. The static flow table indicates the vSwitch to modify destination MAC addresses of all packets whose destination MAC addresses are BB to the MAC address of an actual external network gateway A, and the vSwitch forwards the flow to the actual external network gateway A.

[0060] If the MAC address of the logical external network gateway has been set as the MAC address of the actual external network gateway A, the process of modifying the destination MAC addresses may be omitted.

[0061] FIG. 5 is a diagram illustrating a process of forwarding a flow accessing an external network when accessing the external network from a virtual network according to an example of the present disclosure.

[0062] The next hop of the VM in the default routing is the logical external network gateway. Accordingly, when the VM is to access an address of the external network, for example, access a server whose IP address is 1.1.1.1, the VM finds that the IP address matches the default routing, and thus sets the destination IP address of a packet as 1.1.1.1, and sets the destination MAC address of the packet as the MAC address of the logical external network gateway after checking the ARP entry.

[0063] As shown in a packet flow in FIG. 5, after the packet arrives at the vSwitch, the vSwitch performs matching for the packet according to a distributed flow entry whose destination MAC address is BB. According to the flow entry, the vSwitch modifies the destination MAC address of the packet to the MAC address of the actual external network gateway A, and then forwards the packet to the actual external network gateway A.

[0064] The examples shown in FIGS. 2-5 are described based on a case that one

logical external network gateway is created and there is one actual external network gateway.

[0065] If there are multiple network segments that are to interwork with the external network in the virtual network, one logical external network gateway is created for each network segment, and the routing information indicates that the logical external network gateway is the next hop of the VM in the network segment in the default routing. For example, VM1-VM3 belong to a network segment 1, VM4-VM6 belong to a network segment 2, a logical external network gateway 1 is created for the network segment 1 and a logical external network gateway 2 is created for the network segment 2. Accordingly, the routing information distributed to VM1-VM3 indicates that the next hop of a flow to be sent to the external network is the logical external network gateway 1, and the routing information distributed to VM4-VM6 indicates that the next hop of a flow to be sent to the external network is the logical external network gateway 2.

[0066] If there are multiple actual external network gateways in the virtual network, the flow table distributed to the switch by the controller indicates that the flow is to be forwarded to the actual external network gateway corresponding to the logical external network gateway to which the destination MAC address of the flow belongs. For example, suppose the logical external network gateway 1 and the logical external network gateway 2 correspond to the actual external network gateway 1, and the logical external network gateway 3 and the logical external network gateway 4 correspond to the actual external network gateway 2. The controller distributes the flow table 1, and the flow table 1 indicates that a flow whose destination MAC address is the MAC addresses of the logical external network gateway 1 and the logical external network gateway 2 is to be forwarded to the actual external network gateway 1. The controller also distributes the flow table 2, and the flow table 2 indicates that a flow whose destination MAC address is the MAC addresses of the logical external network gateway 3 and the logical external network gateway 4 is to be forwarded to the actual external network gateway 2.

[0067] In the example of the present disclosure, the controller of the distributed switch may interwork with a module that runs in the VM and can receive the routing table and the ARP entry. For example, the controller distributes the routing table and the ARP entry to a configuration module such as VM tools. The routing table indicates that the next hop of the VM in the default routing is the logical external network gateway, and the ARP entry indicates the MAC address of the next hop of the VM in the default routing. In

this way, a tag may be attached on a packet accessing the external network. That is, the destination MAC address of the packet accessing the external network is set as the MAC address of the logical external network gateway. The controller also distributes the static flow table to the switch, and the static flow table indicates the switch to forward the packet attached with the tag to the logical external network gateway.

[0068] In an example of the present disclosure, the VM has the routing information for indicating that the flow to be sent to the external network is to be sent to the logical external network gateway, and thus the VM may attach a tag on the flow according to the routing information. The switch has a flow table for indicating the forwarding of the flow attached with the tag. Accordingly, after recognizing the flow attached with the tag, the switch forwards the flow attached with the tag to the actual external network gateway according to the flow table. Accordingly, it is unnecessary to send to the controller the initial packet of the flow to be sent to the external network, thereby avoiding that the controller becomes the bottleneck and improving system performance.

[0069] In various examples of the present disclosure, the flow table in the switch is configured based on the MAC address of the logical external network gateway, and the logical external network gateway is created based on a network segment instead of a single IP address. Accordingly, for each logical external network gateway, it is unnecessary to distribute a flow table for each IP address of the external network, but necessary to distribute one flow table to the switch. In this case, the number of distributed flow tables may be reduced, a flow table matching efficiency may be increased and system performance may be improved.

[0070] Based on the above method, examples of the present disclosure also provide an apparatus for accessing an external network from a virtual network, a flow routing apparatus and a flow forwarding apparatus.

[0071] FIG. 6 is a diagram illustrating the structure of an apparatus for accessing an external network from a virtual network according to an example of the present disclosure. The apparatus may be applied to a controller shown in FIG. 7.

[0072] As shown in FIG. 6, the apparatus includes a logical external network gateway creating module 801, a routing distributing module 802 and a flow table distributing module 803.

[0073] The logical external network gateway creating module 801 may create a logical external network gateway.

[0074] The routing distributing module 802 may distribute routing information and ARP entry information to a VM. The routing information indicates that the next hop of a flow to be sent to the external network is the logical external network gateway, and the ARP entry information includes the MAC address of the logical external network gateway.

[0075] The flow table distributing module 803 may distribute a flow table to a switch. The flow table indicates that a flow whose destination MAC address is the MAC address of the logical external network gateway is to be forwarded to an actual external network gateway.

[0076] Each network segment that is in the virtual network and is to interwork with the external network corresponds to one logical external network gateway. MAC addresses of multiple logical external network gateways corresponding to the same actual external network gateway are the same, and MAC addresses of multiple logical external network gateways corresponding to different actual external network gateways are different.

[0077] The logical external network gateway creating module 801 may set the MAC address of the logical external network gateway as a pre-configured MAC address.

[0078] The flow table may further indicate that the destination MAC address of a flow whose destination MAC address is the MAC address of the logical external network gateway is modified to the MAC address of an actual external network gateway corresponding to the logical external network gateway, and then the flow is forwarded to the actual external network gateway.

[0079] The logical external network gateway creating module 801 may set the MAC address of each logical external network gateway as the MAC address of an actual external network gateway corresponding to the logical external network gateway.

[0080] The routing information is distributed to each VM in the network segment and indicates that the next hop in the default routing is a logical external network gateway created for the network segment.

[0081] The routing information further indicates that the next hop in internal routing of the virtual network is an internal gateway of the virtual network.

[0082] FIG. 7 is a diagram illustrating the hardware structure of a controller according to an example of the present disclosure. As shown in FIG. 7, the controller includes a non-transitory storage 701 and a processor 702. The above hardware

components are connected to each other via buses.

[0083] The non-transitory storage 701 may store machine readable instructions, including logical external network gateway creating instructions, routing distributing instructions and flow table distributing instructions. When the machine readable instructions are executed by the processor 702, the functions of the apparatus shown in FIG. 6 can be implemented.

[0084] The processor 702 may communicate with the non-transitory storage 701, read and execute the machine readable instructions stored in the non-transitory storage 701 to implement the functions of the apparatus shown in FIG. 6.

[0085] FIG. 8 is a diagram illustrating the structure of a flow routing apparatus according to an example of the present disclosure. The apparatus may be applied to a VM shown in FIG. 9.

[0086] As shown in FIG. 8, the flow routing apparatus includes a routing receiving module 1001, a flow recognizing module 1002 and a flow routing module 1003.

[0087] The routing receiving module 1001 may receive routing information and ARP entry information. The routing information indicates that the next hop of a flow to be sent to an external network is a pre-created logical external network gateway, and the ARP entry information includes the MAC address of the logical external network gateway.

[0088] The flow recognizing module 1002 may recognize the flow to be sent to the external network.

[0089] The flow routing module 1003 may route the flow to be sent to the external network to the logical external network gateway.

[0090] The routing information may be distributed to each VM in the network segment and indicate that the next hop in default routing is the logical external network gateway created for the network segment and the next hop in internal routing is an internal gateway of a virtual network.

[0091] The flow recognizing module 1002 may recognize whether the destination IP address of a flow is an address of the external network or an internal address of the virtual network when the destination IP address of the flow and the IP address of the VM do not belong to the same network segment.

[0092] The flow routing module 1003 may set the destination MAC address of the flow as the MAC address of the next hop in the default routing when the destination IP

address of the flow is the address of the external network, and set the destination MAC address of the flow as the MAC address of the next hop in the internal routing when the destination IP address of the flow is the internal address of the virtual network.

5 [0093] FIG. 9 is a diagram illustrating the hardware structure of a VM according to an example of the present disclosure. As shown in FIG. 9, the VM includes a non-transitory storage 901 and a processor 902. The above hardware components are connected to each other via buses.

[0094] The non-transitory storage 901 may store machine readable instructions, including routing receiving instructions, flow recognizing instructions and flow routing
10 instructions. When the machine readable instructions are executed by the processor 902, the functions of the apparatus shown in FIG. 8 can be implemented.

[0095] The processor 902 may communicate with the non-transitory storage 901, read and execute the machine readable instructions stored in the non-transitory storage 901 to implement the functions of the apparatus shown in FIG. 8.

15 [0096] FIG. 10 is a diagram illustrating the structure of a flow forwarding apparatus according to an example of the present disclosure. The apparatus may be applied to a switch shown in FIG. 11.

[0097] As shown in FIG. 10, the flow forwarding apparatus includes a flow table receiving module 1201, a flow recognizing module 1202 and a flow forwarding module
20 1203.

[0098] The flow table receiving module 1201 may receive a flow table. The flow table indicates that a flow whose destination MAC address is the MAC address of a logical external network gateway is to be forwarded to an actual external network gateway.

25 [0099] The flow recognizing module 1202 may recognize the flow whose destination MAC address is the MAC address of the logical external network gateway.

[0100] The flow forwarding module 1203 may forward the flow whose destination MAC address is the MAC address of the logical external network gateway to the actual external network gateway.

30 [0101] The MAC address of the logical external network gateway may be a pre-configured MAC address.

[0102] The flow table may further indicate that the destination MAC address of the flow whose destination MAC address is the MAC address of the logical external network

gateway is modified to the MAC address of an actual external network gateway corresponding to the logical external network gateway, and then the flow is forwarded to the actual external network gateway.

[0103] The flow forwarding module 1203 may modify the destination MAC address of the flow whose destination MAC address is the MAC address of the logical external network gateway to the MAC address of the actual external network gateway corresponding to the logical external network gateway, and then the flow is forwarded to the actual external network gateway.

[0104] FIG. 11 is a diagram illustrating the hardware structure of a switch according to an example of the present disclosure. As shown in FIG. 11, the switch includes a non-transitory storage 1101 and a processor 1102. The above hardware components are connected to each other via buses.

[0105] The non-transitory storage 1101 may store machine readable instructions, including flow table receiving instructions, flow recognizing instructions and flow forwarding instructions. When the machine readable instructions are executed by the processor 1102, the functions of the apparatus shown in FIG. 10 can be implemented.

[0106] The processor 1102 may communicate with the non-transitory storage 1101, read and execute the machine readable instructions stored in the non-transitory storage 1101 to implement the functions of the apparatus shown in FIG. 10.

[0107] In the examples of the present disclosure, the controller creates a logical external network gateway for each network segment that is in the virtual network and is to interwork with the external network, and distributes the routing information and the ARP entry information to the VM. The routing information indicates that the next hop of the flow to be sent to the external network is the logical external network gateway. The ARP entry information includes the MAC address of the logical external network gateway. The controller distributes a flow table to the switch. The flow table indicates that the flow whose destination MAC address is the MAC address of the logical external network gateway is to be forwarded to an actual external network gateway.

[0108] In the examples of the present disclosure, an actual external network gateway is set, by which the virtual network can be connected to the external network. A flow passes through the actual external network gateway when accessing the external network. The actual external network gateway may be a physical external network gateway or a virtual external network gateway. In the examples of the present disclosure,

a logical external network gateway is created for a network segment that is in the virtual network and is to interwork with the external network. The controller distributes routing information and ARP entry information to the VM, and distributes a flow table to the switch. The routing information indicates that the next hop of a flow to be sent to an external network is the logical external network gateway, the flow table indicates that a flow whose destination MAC address is the MAC address of the logical external network gateway is to be forwarded to an actual external network gateway. The VM sets the destination MAC address of the flow to be sent to the external network as the MAC address of the logical external network gateway according to the routing information and the ARP entry information, thereby attaching a tag on the flow to be sent to the external network. After the VM sends the flow attached with the tag to the switch, the switch recognizes the flow attached with the tag, i.e., the flow whose destination MAC address is the MAC address of the logical external network gateway, and forwards the flow to the actual external network gateway according to the flow table, thereby sending the flow to the external through the actual external network gateway.

[0109] In an example of the present disclosure, the VM has the routing information for indicating that the flow to be sent to the external network is to be sent to the logical external network gateway, and thus the VM may attach a tag on the flow according to the routing information. The switch has a flow table for indicating the forwarding of the flow attached with the tag. Accordingly, after recognizing the flow attached with the tag, the switch forwards the flow attached with the tag to the actual external network gateway according to the flow table. Accordingly, it is unnecessary to send to the controller the initial packet of the flow to be sent to the external network, thereby avoiding that the controller becomes the bottleneck and improving system performance.

[0110] In various examples of the present disclosure, the flow table in the switch is configured based on the MAC address of the logical external network gateway, and the logical external network gateway is created based on a network segment instead of a single IP address. Accordingly, for each logical external network gateway, it is unnecessary to distribute a flow table for each IP address of the external network, but necessary to distribute one flow table to the switch. In this case, the number of distributed flow tables may be reduced, a flow table matching efficiency may be increased and system performance may be improved.

[0111] Although described specifically throughout the entirety of the instant disclosure, representative examples of the present disclosure have utility over a wide range of applications, and the above discussion is not intended and should not be construed to be limiting, but is offered as an illustrative discussion of aspects of the disclosure.

[0112] What has been described and illustrated herein is an example along with some of its variations. The terms, descriptions and figures used herein are set forth by way of illustration only and are not meant as limitations. Many variations are possible within the spirit and scope of the subject matter, which is intended to be defined by the following claims -- and their equivalents -- in which all terms are meant in their broadest reasonable sense unless otherwise indicated.

What is claimed is:

1. A method for accessing an external network from a virtual network, applied to a controller and comprising:

5 distributing routing information and Address Resolution Protocol (ARP) entry information to a Virtual Machine (VM), wherein the routing information indicates that a next hop of a flow to be sent to the external network is a pre-created logical external network gateway, and the ARP entry information comprises a Media Access Control (MAC) address of the logical external network gateway; and

10 distributing a flow table to a switch, wherein the flow table indicates that a flow whose destination MAC address is the MAC address of the logical external network gateway is to be forwarded to an actual external network gateway.

2. The method of claim 1, wherein each network segment that is in the virtual network and is to interwork with the external network corresponds to one logical external network gateway, and the routing information is distributed to each VM in the network segment and indicates that a next hop in default routing is the logical external network gateway created for the network segment and a next hop in internal routing is an internal gateway of the virtual network; and

MAC addresses of multiple logical external network gateways corresponding to the same actual external network gateway are the same, and MAC addresses of multiple logical external network gateways corresponding to different actual external network gateways are different.

3. The method of claim 1, wherein the MAC address of the logical external network gateway is a pre-configured MAC address; the flow table further indicates that a destination MAC address of a flow whose destination MAC address is the MAC address of the logical external network gateway is modified to a MAC address of the actual external network gateway corresponding to the logical external network gateway, and the flow is forwarded to the actual external network gateway.

4. The method of claim 2, wherein a MAC address of each of multiple logical external network gateways corresponding to different actual external network gateways is set as a MAC address of an actual external network gateway corresponding to the logical external network gateway, so that the switch forwards, after receiving the flow whose destination MAC address is the MAC address of the logical external network gateway, the

flow to the actual external network gateway corresponding to the logical external network gateway rather than modifying the destination MAC address of the flow.

5 5. An apparatus for accessing an external network from a virtual network, comprising a logical external network gateway creating module, a routing distributing module and a flow table distributing module;

the logical external network gateway creating module is to create a logical external network gateway;

10 the routing distributing module is to distribute routing information and Address Resolution Protocol (ARP) entry information to a Virtual Machine (VM), wherein the routing information indicates that a next hop of a flow to be sent to the external network is a pre-created logical external network gateway, and the ARP entry information comprises a Media Access Control (MAC) address of the logical external network gateway; and

15 the flow table distributing module is to distribute a flow table to a switch, wherein the flow table indicates that a flow whose destination MAC address is the MAC address of the logical external network gateway is to be forwarded to an actual external network gateway.

20 6. The apparatus of claim 5, wherein each network segment that is in the virtual network and is to interwork with the external network corresponds to one logical external network gateway, the routing information is distributed to each VM in the network segment and indicates that a next hop in default routing is the logical external network gateway created for the network segment and a next hop in internal routing is an internal gateway of the virtual network; and

25 MAC addresses of multiple logical external network gateways corresponding to the same actual external network gateway are the same, and MAC addresses of multiple logical external network gateways corresponding to different actual external network gateways are different.

30 7. The apparatus of claim 5, wherein the logical external network gateway creating module is to set the MAC address of the logical external network gateway as a pre-configured MAC address; the flow table further indicates that a destination MAC address of a flow whose destination MAC address is the MAC address of the logical external network gateway is modified to a MAC address of the actual external network gateway corresponding to the logical external network gateway, and the flow is forwarded

to the actual external network gateway.

8. The apparatus of claim 6, wherein the logical external network gateway creating module is to set a MAC address of each of multiple logical external network gateways corresponding to different actual external network gateways as a MAC address of an actual external network gateway corresponding to the logical external network gateway, so that the switch forwards, after receiving the flow whose destination MAC address is the MAC address of the logical external network gateway, the flow to the actual external network gateway corresponding to the logical external network gateway rather than modifying the destination MAC address of the flow.

9. A flow routing apparatus, applied to a Virtual Machine (VM) and comprising a routing receiving module, a flow recognizing module and a flow routing module;

the routing receiving module is to receive routing information and Address Resolution Protocol (ARP) entry information, wherein the routing information indicates that a next hop of a flow to be sent to an external network is a pre-created logical external network gateway, and the ARP entry information includes a Media Access Control (MAC) address of the logical external network gateway;

the flow recognizing module is to recognize the flow to be sent to the external network; and

the flow routing module is to route the flow to be sent to the external network to the logical external network gateway.

10. The flow routing apparatus of claim 9, wherein each network segment that is in a virtual network and is to interwork with the external network corresponds to one logical external network gateway, and for each VM in the network segment, the routing information indicates that a next hop in default routing is the logical external network gateway created for the network segment and a next hop in internal routing is an internal gateway of the virtual network;

the flow recognizing module is to recognize whether a destination IP address of a flow is an address of the external network or an internal address of the virtual network when the destination IP address of the flow and an IP address of the VM do not belong to the same network segment; and

the flow routing module is to set a destination MAC address of the flow as a MAC address of the next hop in the default routing when the destination IP address of the flow is the address of the external network, and set the destination MAC address of the flow as

a MAC address of the next hop in the internal routing when the destination IP address of the flow is the internal address of the virtual network.

11. A flow forwarding apparatus, applied to a switch and comprising a flow table receiving module, a flow recognizing module and a flow forwarding module;

5 the flow table receiving module is to receive a flow table, wherein the flow table indicates that a flow whose destination Media Access Control (MAC) address is a MAC address of a logical external network gateway is to be forwarded to an actual external network gateway;

10 the flow recognizing module is to recognize the flow whose destination MAC address is the MAC address of the logical external network gateway; and

 the flow forwarding module is to forward the flow whose destination MAC address is the MAC address of the logical external network gateway to the actual external network gateway.

12. The flow forwarding apparatus of claim 11, wherein the MAC address of the logical external network gateway is a pre-configured MAC address; the flow table further indicates that the destination MAC address of the flow whose destination MAC address is the MAC address of the logical external network gateway is modified to a MAC address of an actual external network gateway corresponding to the logical external network gateway, and the flow is forwarded to the actual external network gateway; and

20 the flow forwarding module is to modify the destination MAC address of the flow whose destination MAC address is the MAC address of the logical external network gateway to the MAC address of the actual external network gateway corresponding to the logical external network gateway, and the flow is forwarded to the actual external network gateway.

25 13. A non-transitory storage, comprising machine readable instructions, which are executed by a processor of a controller to implement a process of:

 distributing routing information and Address Resolution Protocol (ARP) entry information to a Virtual Machine (VM), wherein the routing information indicates that a next hop of a flow to be sent to the external network is a pre-created logical external network gateway, and the ARP entry information comprises a Media Access Control (MAC) address of the logical external network gateway; and

 distributing a flow table to a switch, wherein the flow table indicates that a flow whose destination MAC address is the MAC address of the logical external network

gateway is to be forwarded to an actual external network gateway.

14. The non-transitory storage of claim 13, wherein each network segment that is in the virtual network and is to interwork with the external network corresponds to one logical external network gateway, and the routing information is distributed to each VM
5 in the network segment and indicates that a next hop in default routing is the logical external network gateway created for the network segment and a next hop in internal routing is an internal gateway of the virtual network; and

MAC addresses of multiple logical external network gateways corresponding to the same actual external network gateway are the same, and MAC addresses of multiple
10 logical external network gateways corresponding to different actual external network gateways are different.

15. The non-transitory storage of claim 14, wherein the MAC address of the logical external network gateway is a pre-configured MAC address; the flow table further indicates that a destination MAC address of a flow whose destination MAC address is the
15 MAC address of the logical external network gateway is modified to a MAC address of the actual external network gateway corresponding to the logical external network gateway, and the flow is forwarded to the actual external network gateway.

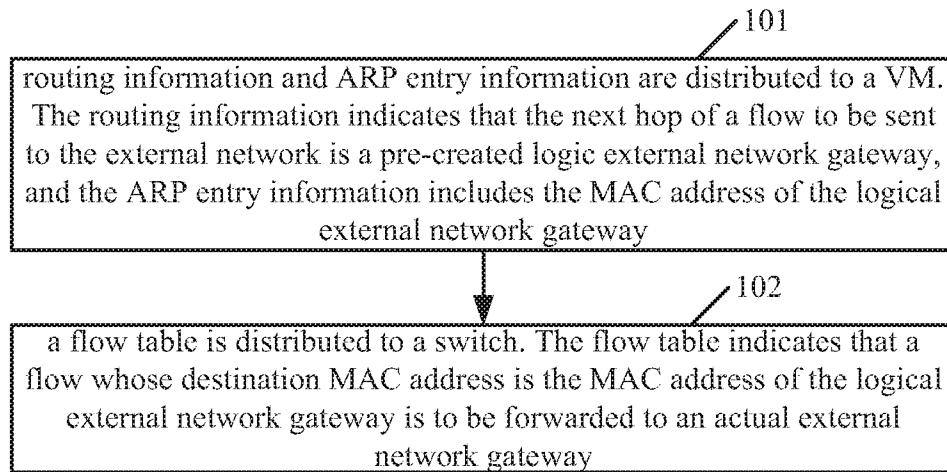


FIG. 1

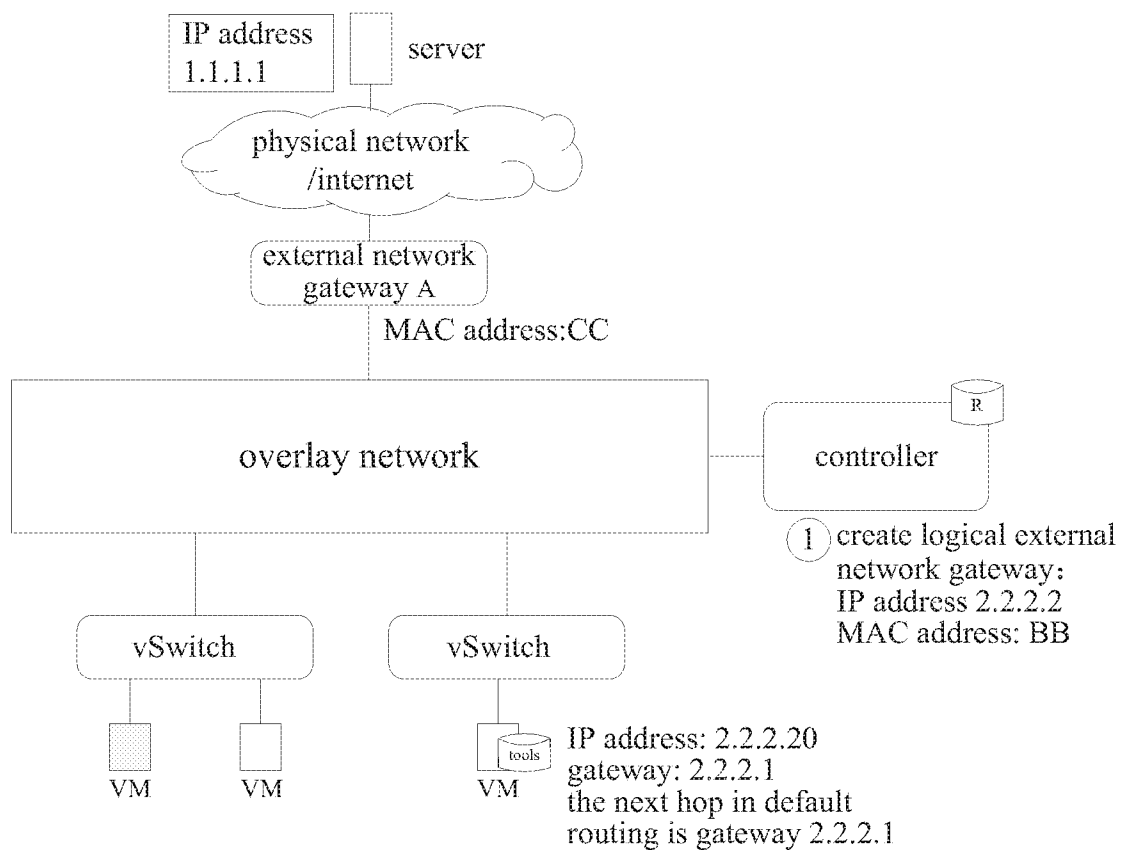


FIG. 2

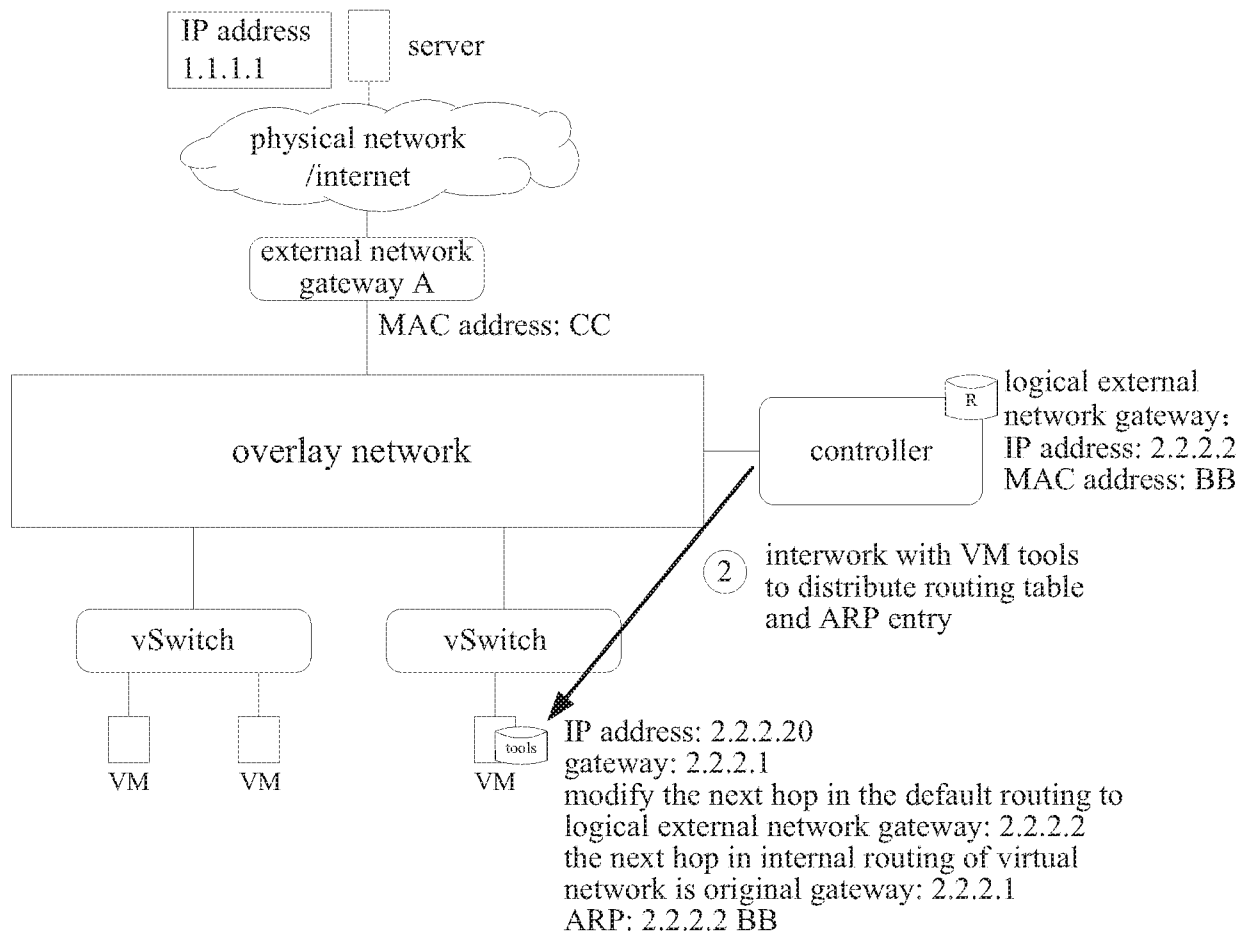


FIG. 3

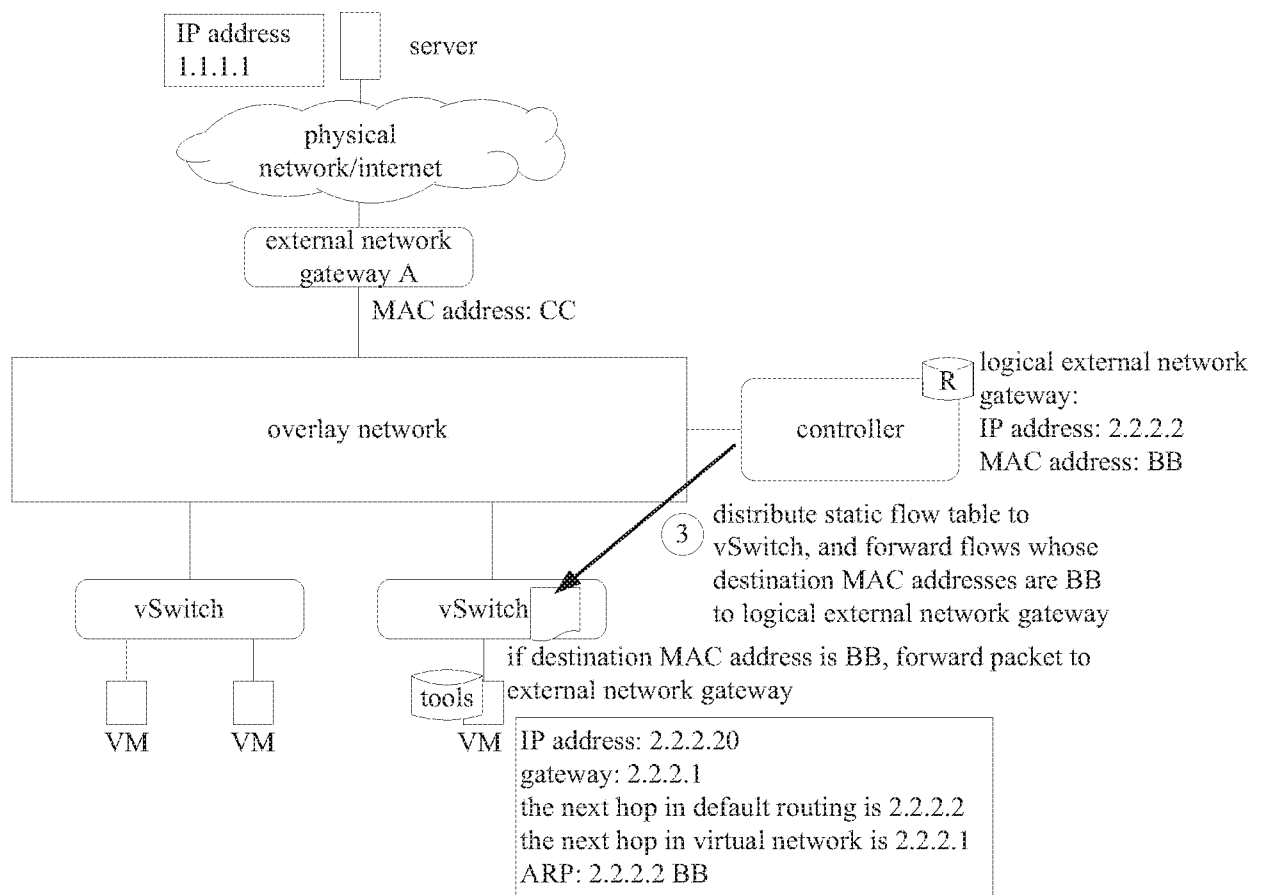


FIG. 4

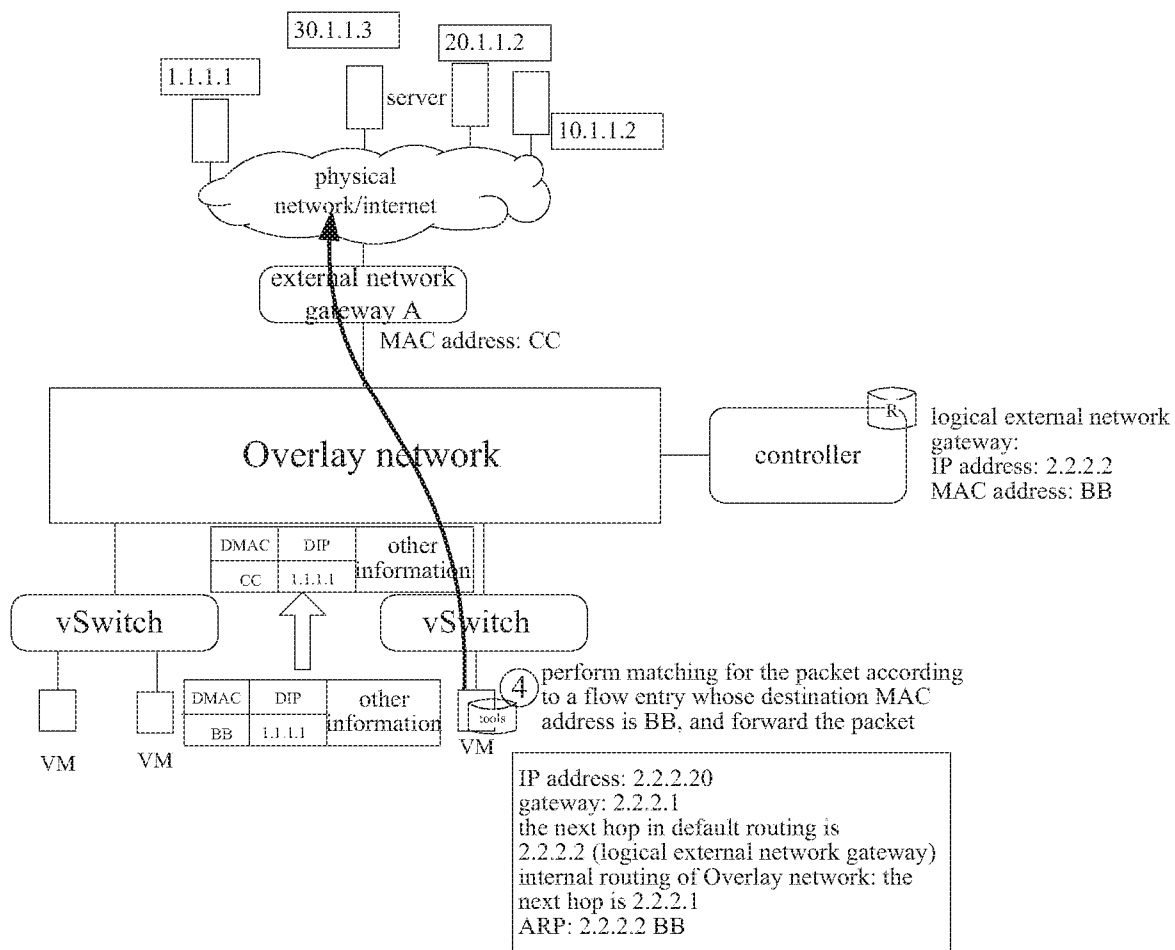


FIG. 5

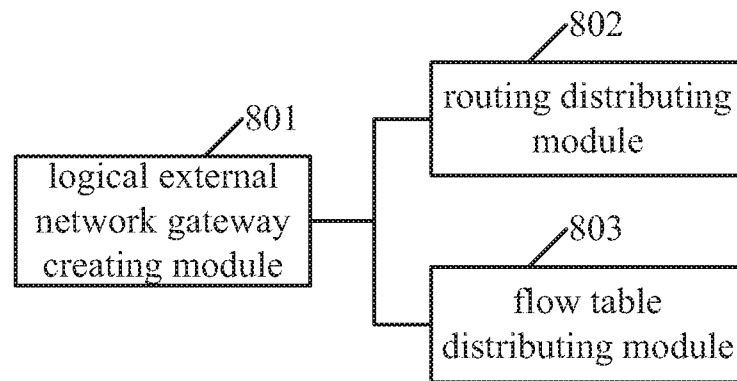


FIG. 6

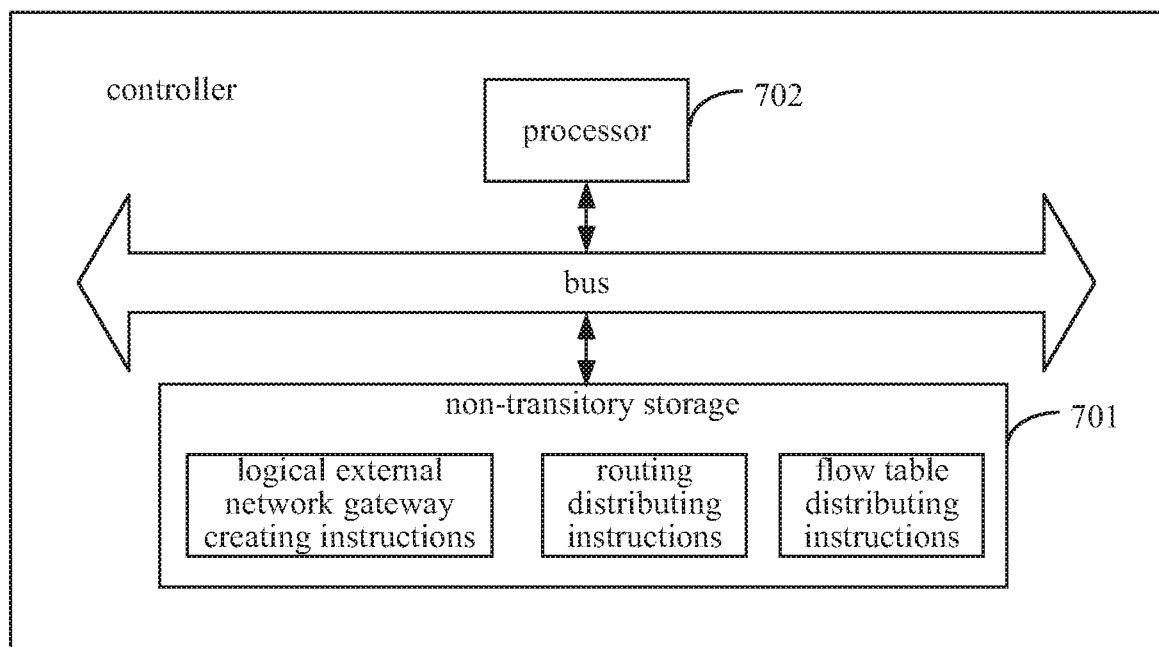


FIG. 7

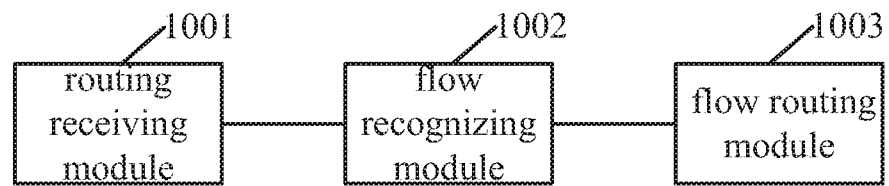


FIG. 8

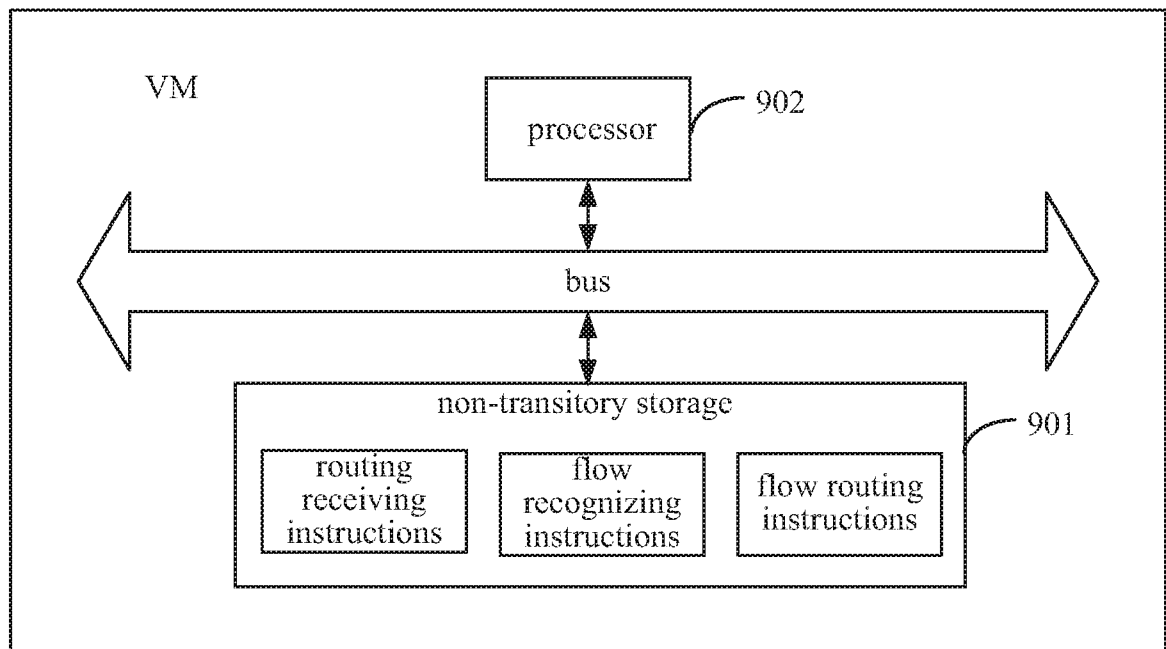


FIG. 9

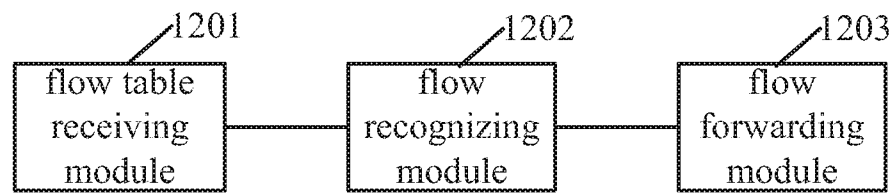


FIG. 10

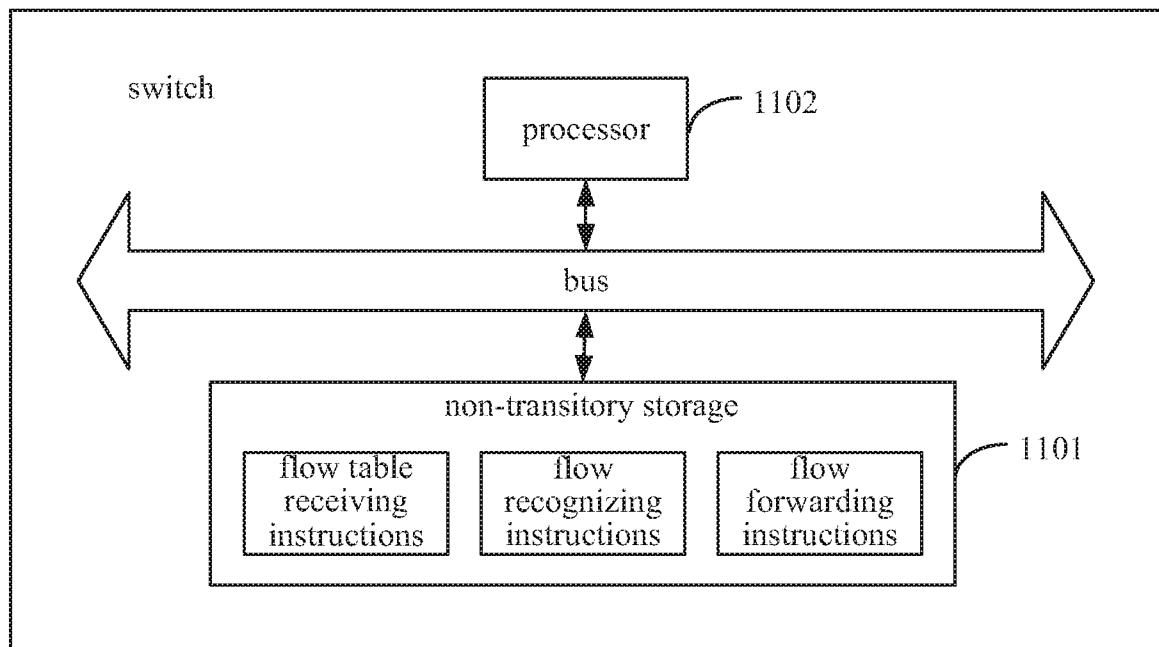


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2015/100064

A. CLASSIFICATION OF SUBJECT MATTER

H04L 29/06(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L; H04W; H04Q; G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT,DWPI,GOOGLE:virtual machine, VM, internet, external network, extranet, rout+, Address Resolution Protocol, ARP, gateway, next hop, logical, Media Access Control, MAC, controller, switch, actual

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2013266019 A1 (FUTUREWEI TECHNOLOGIES, INC.) 10 October 2013 (2013-10-10) the abstract, claims 1, 6	1-15
A	CN 104052666 A (杭州华三通信技术有限公司) 17 September 2014 (2014-09-17) the whole document	1-15
A	CN 102457439 A (中标软件有限公司) 16 May 2012 (2012-05-16) the whole document	1-15
A	CN 102801715 A (华为技术有限公司) 28 November 2012 (2012-11-28) the whole document	1-15
A	US 2013250951 A1 (BROCADE COMMUNICATIONS SYSTEMS, INC.) 26 September 2013 (2013-09-26) the whole document	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

21 March 2016

Date of mailing of the international search report

01 April 2016

Name and mailing address of the ISA/CN

STATE INTELLECTUAL PROPERTY OFFICE OF THE
P.R.CHINA
6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing
100088, China

Facsimile No. (86-10)62019451

Authorized officer

SHANG,Xiaoli

Telephone No. (86-10)62413339

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2015/100064

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
US	2013266019	A1	10 October 2013	EP	2832053	A4	11 November 2015
				US	8923155	B2	30 December 2014
				US	8923149	B2	30 December 2014
				US	2013266015	A1	10 October 2013
				CN	104170331	A	26 November 2014
				WO	2013152716	A1	17 October 2013
				EP	2832053	A1	04 February 2015
CN	104052666	A	17 September 2014	WO	2014139462	A1	18 September 2014
				US	2016014025	A1	14 January 2016
				EP	2974234	A1	20 January 2016
CN	102457439	A	16 May 2012	CN	102457439	B	28 May 2014
CN	102801715	A	28 November 2012	CN	102801715	B	11 March 2015
US	2013250951	A1	26 September 2013	CN	104285416	A	14 January 2015
				US	9154416	B2	06 October 2015
				EP	2829031	A1	28 January 2015
				US	2016028626	A1	28 January 2016
				WO	2013142519	A1	26 September 2013