Open eXchange Protocol

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1 Introduction

Open eXchange protocol is an efficient west-east bound protocol for SDN control plane, which supports heterogeneous controllers to cooperate with each other. OXP provides simple, advanced, compressed and normal modes for adapting to various network scenarios. This specification describes the design of Open eXchange protocol, including controller components, glossary, Open eXchange channel and Open eXchange protocol(OXP).

1.1 About multi-controller

The limit scalability of control plane restricts the scale of SDN. A large scale network should be partitioned into several smaller network which controlled by a network operating system alone when deploying SDN. Therefore, multi-controller will be deployed on a large scale network. However, many services require a global network view. Therefore, the west-east bound communication interface is needed for controllers to cooperate.

There are two types of architecture on multi-controller: horizontal architecture and vertical architecture. In horizontal architecture, controllers establish peer-to-peer connections. Controller can fetch data from its peers. In vertical architecture, there is a master/super controller over the individual/domain controller. The master/super controller maintains the global network view cross the connected SDN domain networks. Thus, Super can manage the global communication.

1.2 OXP architecture

The architecture of OXP is vertical. OXP separates the control plane into two layers: super controller layer and domain controller layer. Super controller is in charge of the inter-domain network while the domain controller manages the domain network. The architecture of OXP shows in Figure 1.

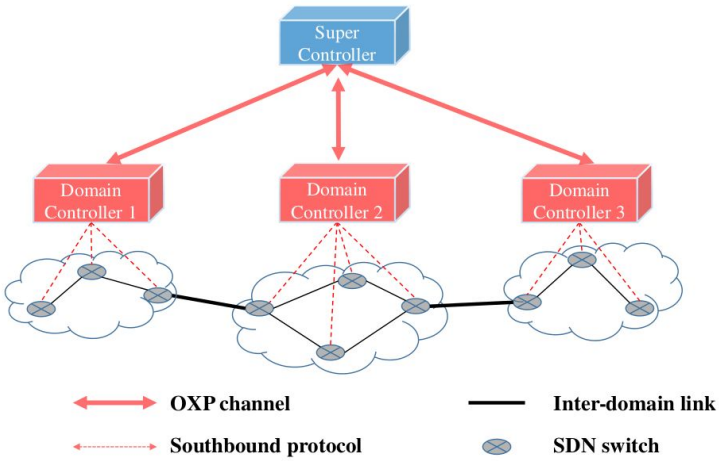

Figure.1 Open eXchange protocol architecture

2 Controller components

There are two types of controller, domain controller and super controller. Each domain controller controls the domain network, while super controller is in charge of the inter-domain network. This section will describe the design of domain controller and super controller.

For security, privacy and efficiency, each domain network would be abstracted into a BigSwitch in OXP architecture, which hides the detail network information of domain network. After abstraction, each domain network only exposes the outer ports that facing to other domain networks. For the super controller, entire network view only includes BigSwitches and inter-domain links between BigSwitches. (see 2.1.1)

When cross-domain forwarding request occurs, domain controller will send it to super controller. After receiving forwarding request, super controller will compute an inter-domain path based on entire abstraction network view. The inter-domain path shows in Figure 2. According to the computation result, super controller sends the forwarding reply to all BigSwitches along the path. Once domain controller receives a forwarding reply, it will translate the forwarding reply into southbound protocol messages. Finally, the result of translation will be installed into switches, so that the packet can be forwarded successfully. In this way, a computation of cross-domain path is divided into two parts: intra-domain computation and inter-domain computation, which lowers the computation complexity remarkably.

In order to adapt to various network scenarios, OXP designs multi modes, including simple (see 4.1), advanced (see 4.2), compressed (see 4.3) and normal (see 4.4). When the quality of OXP channel can't be guaranteed, it is recommended to establish OXP channel in simple mode, which costs less bandwidth. Otherwise, it is recommended to establish OXP channel in advanced mode so that super controller can make an optimal decision. Compressed mode is designed for the network scenarios with inadequate link capability. In compressed mode, the messages of service like forwarding request will be simplified. In the contrast, the information can be exchanged based on the southbound protocol directly in normal mode, which maintains the entire programmability of southbound protocol.

2.1 Domain controller

In OXP architecture, domain controller only manages the intra-domain network. Each domain will be identified by a unique domainID, which is similar to datapath ID of switch in OpenFlow protocol. After the OXP channel established, domain controller needs to abstract the domain network. Also, domain controller needs to synchronize the specific network information to super controller according to the setting of OXP channel.

2.1.1 Network Abstraction

Network abstraction not only reduces the cost of synchronization but also enhances the security of domain network. In OXP architecture, each domain network would be abstracted into a logical switch referred to as a BigSwitch. We illustrate the network abstraction in Figure 2. The outer ports of domain network are reflected into vports of BigSwitch, while the best paths between outer ports become the paths of switch matric of BigSwitch. In advanced mode of OXP, domain controller needs to send the capability of intra-domain paths among outer ports to super controller. Otherwise, domain controller only synchronizes the information of outer ports.

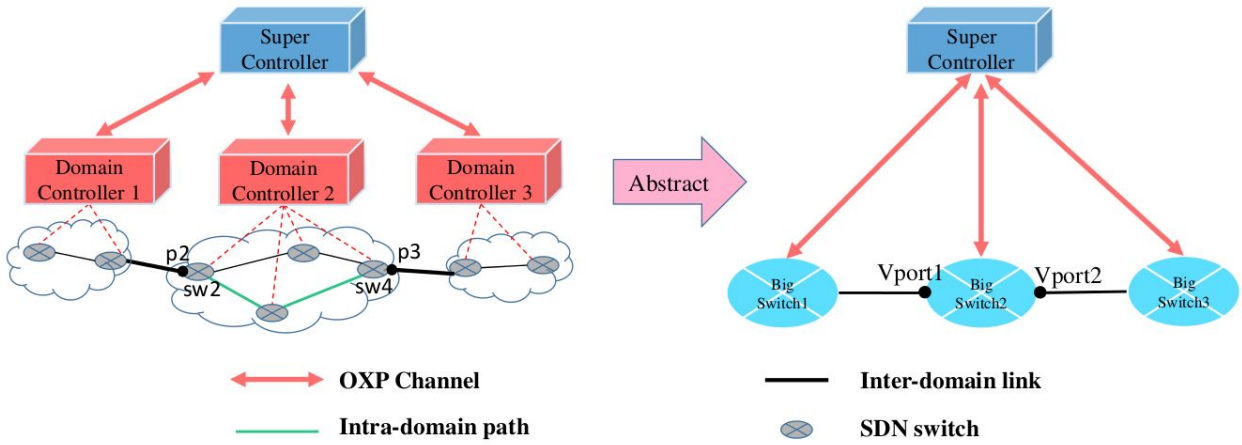

Figure.2 Network abstraction of Open eXchange Protocol

2.1.2 Link capability

For easy understanding different links of entire network, OXP defines intra-domain path and inter-domain link. The intra-domain path is the path between outer ports of domain network while the inter-domain link is the link between domain networks. We illustrate links at Figure2. OXP supports three types of link capabilities for computing path: hop, bandwidth and latency.

Domain controller discovers links via sending LLDP packets with datapath_id, port_no, domain_id and vport_no information. If domain controller receives a LLDP packet with another domain ID from a port, domain controller will mark it as an outer port with a unique vport_no. Also, domain controller should send those LLDP packets that from other domains to super controller so that super controller can discover inter-domain links.

2.1.3 Host information

Domain controller is in charge of the domain network. In order to forward packets, domain controller needs to collect the host information which includes MAC, IP, mask and state. Moreover, domain controller also needs to send the host information to super controller asynchronously, so that super controller can make a forwarding decision based on it.

2.2 Super controller

Super controller is in charge of the inter-domain communication. Super controller collects information of BigSwitches and inter-domain links to generate an abstract entire network topology. Moreover, for forwarding packets cross the entire network, super controller also needs to collect the host location information.

2.2.1 Topology

Super controller collects the entire network topology to manage cross-domain communication. Due to the network abstraction, entire network view is simplified into a simple and abstract topology which only includes BigSwitches and inter-domain links. The topology information shows in Table 1, including the information of domain network and inter-domain links. Domain network information includes domain ID, intra-domain paths and vports while each inter-domain link item contains 3 columns: src_domain_id, dst_domain_id and capabilities. In simple mode, the information of domain network only contains domain ID and vport. While in advanced mode, the entire network topology contains all information shows in Table 1.

Table.1 Topology information

	Key	**Columns**
Domains	Domain id	Intra-domain paths, Vports, Paths, Capabilities, Host location
	Intra-domain paths	Src_Vport, Dst_Vport, Capabilities
	Vports	Vport_no, State
	Host location	Domain_id, IP, MAC, Mask, State
Inter-domain links	Link	Src_domain_id, Dst_domain_id, Capabilities

2.2.2 Link capability

The link capability is the same as the link capability of domain controller's. (See 2.1.2)

2.2.3 Host information

In order to locate the destination host, super controller needs to collect all host information including IP, MAC, mask and state. When domain controller discovers a new host, domain controller will not only record the location, but also send the host information to super controller. Super controller stores the information in database corresponding to the domain ID.

END for confidence.