VCP: A Virtualization Cloud Platform for SDN Intra-domain Production Network

Pingping Lin, Jun Bi, Hongyu Hu
Network Research Center, Department of Computer Science, Tsinghua University
Tsinghua National Laboratory for Information Science and Technology
4-204, FIT Building, Beijing, 100084, China
linpp@netarchlab.tsinghua.edu.cn, junbi@tsinghua.edu.cn, huhongyu@cernet.edu.cn

Abstract— **Software Defined Networking (SDN) is considered as a promising method to re-construct the architecture of Internet. At present, the programs of network protocols are mixed together in SDN controller. However, in the production network, an isolated network environment with private resources is needed for each network protocol running on the same SDN controller. It is therefore necessary to design a practical virtualization cloud platform on the SDN network operating system (NOS). In this paper, we introduce a virtualization cloud platform for SDN production network. A prototype is implemented and two cases are performed to show the feasibility and the effectiveness of our proposed framework.**

Keywords- Software Defined Networking; Virtualization Cloud Platform.

I. INTRODUCTION

Software defined networking (SDN) [1] decouples the vertically integrated network architecture by separating the control plane and data plane. In the meanwhile, it opens up the control plane and the protocol implementation in control plane. The concept of SDN is to promote the rapid growth of network innovations. This is well received by both academic researchers and industry researchers, and SDN is considered as a promising method to re-construct the architecture of Internet.

The studies on SDN have been just touched, which is not mature in many aspects. Recently, several instances of SDN such as OpenFlow [2] and NOSes such as NOX [5] were proposed. However, at present programs of APPs (applications, refer to network protocols such as interior gateway protocols, topology calculation, and new network architectures) on NOS are mixed together. This is feasible in experimentation but not allowed in the production network with the following aspects:

- Security. APPs are always conflicting with each other in flowtable entries in forwarding layer. For example, the Traffic Engineering APP requires a switch to forward a certain data flow to port 2 while the Multipath Routing APP requires forwarding to port 5.
- Performance. Each APP needs an isolated environment with private network resources (if one APP occupies too many resources, other APPs on the same NOS may not work properly at the same time).
- Customer specific networks. APPs always need a specific or virtualized network [1] view from users such as the access network and the edge network.

Based on those special requirements in production network, this paper proposes a virtualization cloud platform located upon NOS as the running environment for APPs.

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II. VIRTUALIZATION CLOUD PLATFORM

As shown in Fig. 1, NOS hides the heterogeneity of the underlying forwarding hardware. Moreover, NOS is capable of perceiving the network state. That is, NOS can collect physical network state and deliver it to VCP above. VCP provides cloud services to APPs such as hosting and network services during the entire APP life cycle, including deduction phase, emulation phase, and operation phase. VCP responses system calls and provides the standardized NetAPI (Network Application Programming Interface) to various APPs.

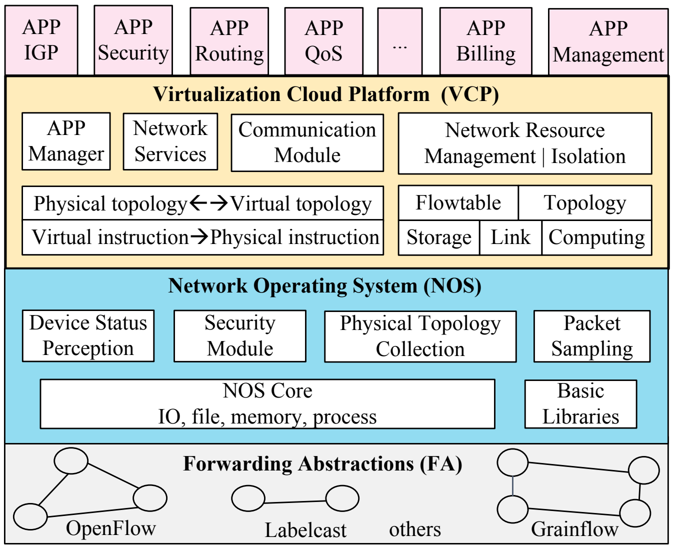

Figure 1. High Level Architecture of SDN with VCP.

A. Network Resource Virtualization

The physical network resources in SDN refer to the flowtable in forwarding device, topology, link bandwidth, and system resources on VCP servers. The virtualization techniques on the system resources are mature. This paper focuses on the rest three aspects. **1) Topology abstraction and virtualization:** The VCP describes the physical topology by directed graph. Besides the full physical topology, network APPs always need specific topologies [1] such as the access network and the edge network which is shown in Fig. 2. VCP is responsible for calculating, embedding, and maintaining the specified virtual topologies for APPs. **2) Flowtable virtualization:** As different specific networks may use the same forwarding devices and their corresponding APPs always conflict with each other in flowtable entries. Thus, the flowtable in forwarding layer is necessary to be virtualized. OpenFlow, a representative SDN instance, applies VLAN (Virtual Local Area Network) technology to the network virtualization. However, the length of VLAN-ID is 12 bits, which means the OpenFlow can only support 4096 virtual networks simultaneously. Furthermore, each port of the forwarding device cannot be shared by different virtual networks but configured on one fixed VLAN. Thus, we define an APP-ID (a 24bits label, can be stored in the options in IPv4 header or in the hop by hop options in IPv6 extension header). At the same time, we extend the flowtable by adding the APP-ID field. In this way, different specific networks can share the same port, and all the flowtable entries with the same APP-ID consist of one virtual flowtable.

Furthermore, through OpenFlow instructions in flowtable, VCP can mark the packets with the APP-ID labels at the first upstream switch directly connected to end hosts. Then, the packets can be processed according to the virtual flowtable whose APP-ID is equal to the APP-ID in packets. In such way, the flowtable conflict problem can be resolved.

3) Link bandwidth virtualization: APP can apply for a certain bandwidth with each virtual link. VCP monitors the bandwidth usage by counting the number of the packets with a same APP-ID forwarded by a virtual device in a unit time.

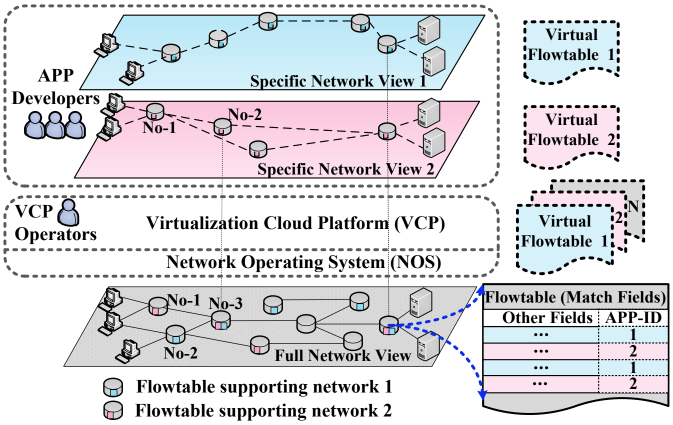

Figure 2. Topology and Flowtable Virtualization.

B. Mapping Specific Network to Physical Network

Mapping of the specific network includes two aspects: **1) Network view mapping:** According to a certain virtual network embedding algorithm, VCP generates the required network topology and the related network resources after receiving a virtual network request. Then, VCP maintains the mapping from specific topology to physical topology. **2) Network operation mapping:** APP operates the specific network directly. That is, the VCP needs to translate the instructions from the specific network to the physical network. For example, an instruction to the virtual node {drop packets in No-2 with source IP address 16.11.32.20} is translated into {drop packet in No-3 with source IP address 16.11.32.20} for physical node in Fig. 2.

C. APP Management Mechanism in VCP

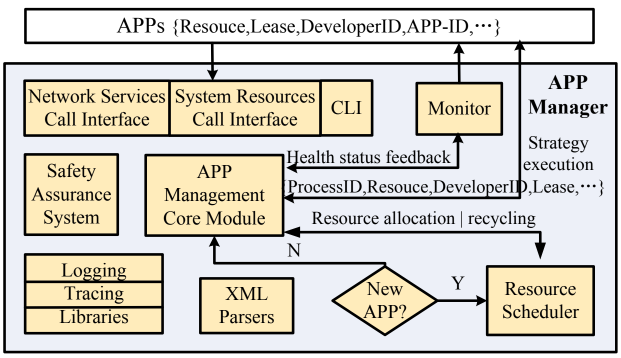

Figure 3. Components Cooperation Mechanism of APP Manager.

Furthermore, a component cooperation mechanism for the APP manager in VCP is designed, as shown in Fig. 3.

D. Entity and Mapping Storage

The entities information and the mapping relationships are all stored in databases (DBs): 1) APP DB: stores APP-ID, life cycle, corresponding specific network and et al. 2) Complete physical network information DB. 3) Specific networks information DB. 4) Mapping Relationship DB.

III. EXPERIMENT AND EVALUATION

As shown in Fig. 4, a prototype is implemented and installed. Two cases are carried out upon the VCP prototype: 1) APP-DIA [3], an inter-AS source address verification protocol with an edge network view; 2) APP-Pathlet Routing [4] with a full network view. APPs in different ASes exchange the pathlets information and perform the pathlet routings.

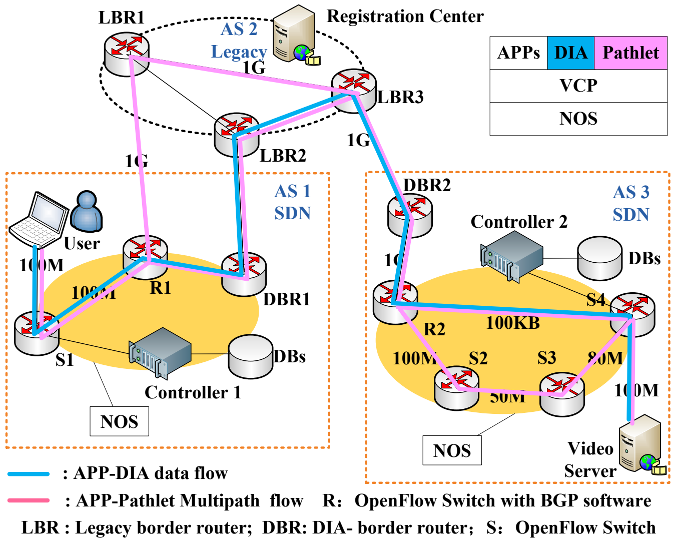

Figure 4. Prototype and Test Cases.

Evaluation: 1) Feasibility: The workflows shown in Fig. 4 validate the feasibility of the VCP. 2) Effectiveness: The two cases on the VCP are running independently without influences by each other. 3) Performance: The performance of VCP is directly related to the instruction translation. As illustrated in Table I, the time delay after adding the VCP is 0.0054s which is equivalent to traversing one more hop of switch. Thus, VCP is effective enough to be used in production network.

TABLE I: TIME DELAY AFTER IMPLEMENTING VCP

Time Delay Composition	Mapping DB Lookup	Data Fetching	Data Substitution
Time Cost	0.003s	0.002s	0.0004s

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