Experimental Demonstration of Multi-Domain Software Defined Optical Network for Time-Varying Traffic

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Abstract Summary

We present a datacenter resources integrated provisioning (DRIP) architecture for time-varying traffic utilizing coordination of distributed datacenters and operator’s multi-domain software defined optical network. The overall feasibility and efficiency are investigated on our testbed.

Introduction

With the advent of cloud computing and data centers (DC), IT resources (i.e., computing resources and storage resources) virtualization are considered in an elastic manner to provide for different tenants and different applications. Optical network, as a strong candidate to support various cloud computing services which are remote and geographically distributed, could provide energy-efficiency, dynamic control, and recent technology advancements including software defined optical network (SDON) support [1, 2]. With the emergence of novel service models (e.g., virtual DC (VDC) request [3]), optical networks and DC infrastructures should be jointly taken into consideration.

DRIP over multi-domain SDON

We propose a datacenter resources integrated provisioning (DRIP) architecture based on coordinated optical networks and DC infrastructures, as shown in Fig. 1. In the DRIP model, DC infrastructures, which are empowered by mature virtualization technology, are interconnected by high-performance multi-domain optical network infrastructures. For a VDC request from a tenant, DRIP completes orchestration and optimization of IT resources and optical network resources. Corresponding resources are provided as private integration (slicing) for tenants. Four layers are presented to realize required functions.

Resource Layer consists of all the IT resources and network package device abstractions. IT resources abstraction is extensively exploited by current virtualization technologies. For network devices, extended OpenFlow is adopted as a general control manner [4].

Control Layer is a distributed control plane consists of multiple controllers. Each domain owns one optical controller (OC). OpenFlow agent translates OpenFlow to vendor-specific messages so that devices from different vendors are under unified control. Virtual network manager (VNM) module is responsible for virtualizing network resources in local domain and provides them for the upper layer. Besides, VNM maps received VN request to local physical devices so that lightpath is provisioned.

Coordination Layer uses VMware application programming interface (API) to provide common abstractions of IT resources and monitor the real-time traffic from DCs and hypervisors, respectively. Network coordinator (NC) module provides IT resources allocation and hierarchical virtualization mechanisms for VDC mapping. NC firstly maps a VDC request to several sub virtualization network (SVN) requests based on the scale of optical domains and the amount of domains. Then SVN requests are sent to controllers in different domains. For time-varying traffic and priorit known (deterministic) traffic demands, adaption engine (AE) implements lightpath adaption periodically by elastic spectrum allocation. We propose adaptation strategy (AS) for time-varying traffic. In AS, central frequency is fixed and only the allocated spectrum may vary according to the real-time traffic estimation.

Application Layer consists of various third-party applications including graphical user interface (GUI), VDC requests can be triggered via Restful API as southbound interfaces in our implementation [3].

Interworking procedure for DRIP

Fig. 2 shows the interworking procedure of DRIP for VDC provisioning in the proposed architecture. A VDC request generally includes virtual IT resources interconnection by virtual topology, notifying the locations and attributes of virtual nodes, the requested bandwidth of virtual links. When obtaining a VDC request, NC handles IT resources mapping according to the requirements of computing and storage capability. In order to create virtual machines (VMs) and disks in DC infrastructures, NC accomplishes interworking with DC
According to the amount of domains and the scale of optical domains, a virtual network request is mapped to several SVN requests by NC. Then they are sent to corresponding OCs via VCI. OC maps the SVN request to physical network. After interworking between OC and optical nodes in local domain by extended OpenFlow protocol, OC responds SVN reply messages to NC. Detailed inter-working messages captured by Wireshark are shown in Fig. 3.

**Experimental Demonstration**

The DRIP architecture has been evaluated on the testbed as shown in Fig. 4. We set up a 2 domain optical network with DC networks comprising the deployed control plane and data plane. DC 1 and 2 are emulated with 16 IBM X3650 M3 or M2 servers and 2 Top-of-Rack (ToR) switches (2 Huawei S5700). Traffic from ToR is aggregated to 1 Cisco C3650G switch. VMware vSphere V5.1 hypervisor is installed in each IBM server as the virtualization environment, in which 5-20 virtual machines are installed with CentOS V6.4 OS. In optical domain, 4 OpenFlow enabled transport nodes supporting multi-granularity client side interfaces (e.g., OTUk, Ethernet and STM-N) are equipped in the data plane, which the remaining nodes are realized on an array of VMs which are independent with DC servers.

AS for time-varying traffic is tested compared with the conventional spectrum assignment as the baseline. Failure rate (FR) is described in Fig. 5(a). A better performance is achieved with AS compared to that with baseline. Fig. 5(b) shows that AS also leads to a higher throughput than baseline with the number of VM requests varying. This is because AS allocates spectrum in an elastic manner according to the real-time traffic estimation. Therefore, spectrum resources are saved and higher throughput is achieved.

**Conclusions**

This paper proposes a novel DRIP architecture for time-varying traffic utilizing the coordination of distributed datacenters and operator’s optical network. Experimental results show that AS can achieve lower failure rate and higher network throughput.

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**References**


