Computers and Electrical Engineering 000 (2016) 1–14

Contents lists available at ScienceDirect

Computers and Electrical Engineering

journal homepage: www.elsevier.com/locate/compeleceng

Resource management framework for virtual data center embedding based on software defined networking☆

Jianqiang Ma

School of Public Administration, Beihang University, Beijing 100191, China

ARTICLE INFO

Article history:
Received 24 July 2016
Revised 1 September 2016
Accepted 1 September 2016
Available online xxx

Keywords:
Resource management
Software defined networking (SDN)
Cloud computing
Infrastructure providers (InPs)

ABSTRACT

In cloud computing, service providers can lease resources as needed from infrastructure providers and deploy services. Service providers only need to focus on their own services without considering the equipment cost and maintenance cost. However, traditional infrastructure providers do not guarantee the network performance and bandwidth and only provide resources with virtual machines. With the development of isolation network virtualization technology, especially the concept of software defined network, some researchers suggested that infrastructure providers should provide resources to service providers with the way of virtual data centers so as to solve these problems in the traditional data centers. Although there are many advantages to allocate resources with virtual data centers, it also brings a new challenge that how to meet the diverse needs of service providers and allocate resources at the minimum cost and maximum profit. In order to solve the embedding problem of virtual data centers based on software defined networking (SDN), this paper presents a novel resource management framework for the embedding problem of virtual data centers. It is a heuristic embedding algorithm based on topological potential and modularity and used to improve the acceptance ratio and the infrastructure providers' revenue. Finally, a dynamic monitoring strategy is proposed to select the virtual data center request with a high revenue cost ratio and further maximize the profit of infrastructure providers. A large number of simulation experiments prove that the proposed algorithm can accept more requests with the minimum cost, and improve the revenues of infrastructure providers.

1. Introduction

With the improvement of informatization level, commerce and other aspects, continuous collision and integration have been happened between all walks of life and the Internet industry. Due to the development of next generation computing model, cloud computing will become the information center of "Internet +" society, allow users to pay on demand and use remote computing, network and storage resources anywhere and anytime. In cloud computing, infrastructure providers (InPs) abstract the infrastructure network resource into a pool. Service providers (SP) can pay for the resources from the InPs and deploy their own service or computing tasks. InPs can implement uniform resource management to improve the utilization rate of physical resources and benefits; SPs just need to focus on business logic without spending a lot of in-

☆ Reviews processed and recommended for publication to the Editor-in-Chief by Guest Editor Dr. Z. Zheng.

E-mail address: jianqiangma1979@163.com

http://dx.doi.org/10.1016/j.compeleceng.2016.09.002
0045-7906/

frastructure cost, maintenance knowledge and cost. As a kind of high efficient computing model, cloud computing has been attracting more and more attention of enterprises and research institutions.

However, the current InPs, such as the Amazon's EC2, mainly provide resources for users in the form of a virtual machine (VM) without providing network isolation and bandwidth guarantee. Networks with TCP/IP protocol stack only provide their best service mode, and the traditional service mode exists some problems in network isolation, security, network performance guarantee, automated management and other aspects [1]. In order to solve these problems, researchers suggest InPs to allocate resources to lessees through a virtual data center (VDC) [1–2]. The VDC is a virtual resource collection based on the physical network slice, including virtual machines, virtual switches, virtual routers and the virtual links connecting them [2]. Compared with the traditional mode which only provides VM, allocating resources in the way of VDC can achieve the network isolation and bandwidth guarantee.

The implementation of VDC depends on the network virtualization technology. Compared with the fast developed and mature host virtualization technology, the development of network virtualization is relatively backward. The emergence of the concept and the development of software defined networking (SDN) accelerate the process of network virtualization. SDN separates the control plane from the data forwarding plane, and a controller can be used to cooperatively forward components behavior, get traffic statistics data and monitor topology changes [3]. SDN has the characteristics of centralized control, whole network information acquisition and network function virtualization, which can be used to effectively solve the various problems in the data center [4]. At present, the deployment of SDN application gets great development in the data center. Among them, performance and energy saving are two mainly considered aspects [4–5]. The network virtualization technology based on SDN can effectively and easily establish the VDC on the physical network of a data center, so as to help InPs lease resources in the form of VDC and provide a network isolation and bandwidth guarantee among multiple lessees. As the multiple VDC are logically separate, so SPs can control their own leasehold VDC completely, such as the introduction of custom network protocols and traffic policies.

While providing resources in the form of VDC can solve performance, security and other problems in a data center; but it brings a new challenge of VDC embedding problem at the same time. The VDC embedding problem refers to how to flexibly and effectively request for proper allocation of physical resources for VDC in a data center. An excellent VDC embedding algorithm can help InPs achieve multiple optimization goals, such as the maximization of the utilization rate of resources and benefits, and the minimization of maintenance costs. Although the embedding problem of VDC is similar to the widely studied virtual network (VN), but there are still some differences:

(1) The VN embedding problem is mainly oriented to the wide area network (WAN), while the VDC embedding problem is mainly oriented to the resources allocation in a data center;
(2) The nodes in VN are the forwarding devices in the WAN, and the VDC contains a variety of nodes, such as hosts, routers, switches, storage nodes and so on [1];
(3) For the same request, one physical node in the VN embedding problem can only embed one virtual node [6], while in the cloud computing environment, several VMs of the same VDC can be allocated to one physical host.

This paper mainly discussed the VDC embedding problem in software defined data center. The main contributions are as follows: (1) We propose a framework of data center resources management based on SDN-enabled; (2) We model the VDC embedding problem and analyze the factors that affect InPs' revenue in the process of VDC embedding; (3) We consider various resource requirements (CPU, memory, bandwidth) and VDC reliability requirements, and propose a new resource allocation algorithm; (4) We conduct the extensive simulations, which shows that the proposed algorithm can achieve higher revenue at a relatively low cost. Finally, based on a dynamic monitoring strategy, the VDC request with a high Revenue/Cost ratio is selected for further optimization algorithm.

The remainder of this paper is organized as follows. We describe problems in Section 2. Section 3 and Section 4 respectively present the problem modeling and the proposed VDC embedding algorithm. Experiments and performance evaluation are introduced in Section 5. Finally, we summarize our work and conclude this paper in Section 6.

2. Problem description

2.1. VDC embedding problem and framework of resources management in the data center

InPs possess physical infrastructures and earn profits by leasing resources to SPs. SPs need certain infrastructures to deploy their services or tasks. In order to save equipment cost and maintenance cost, SPs can lease resources from InPs in the form of VDC. First of all, when a SP needs to lease resources, it needs to submit a VDC request specification to the InP, including the topology of VDC, the vCPU amount, memory footprint of each virtual node and the minimum bandwidth of each virtual link. After the InP receives the request, it will allocate physical resources to meet the requirements for VDC according to the state of the underlying network. InPs will receive different VDC requests from different SPs at different time. But InPs cannot predict the arrival time and specific content of the VDC request. So, the VDC embedding problem in this paper is an online embedding problem.

InPs can set up multiple network slices on the underlying network and provide the isolation for different network slices. Each network slice has its own IP address space and does not interfere with each other. From the perspective of SP, it can control its own network slice like a real network, and the underlying network is transparent to it. A SP can not only use the

Please cite this article as: J. Ma, Resource management framework for virtual data center embedding based on software defined networking, Computers and Electrical Engineering (2016), http://dx.doi.org/10.1016/j.compeleceng.2016.09.002