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Network-Aware Virtual Machine Placement in the Cloud

Pramod Gavali[1], S. P. Pingat[2]

[1]Student, Master in Engineering, Department of Computer Engineering, S.K.N.C.O.E, Savitribai Phule Pune University,

[2]Professor, Department of Computer Engineering, S.K.N.C.O.E, Savitribai Phule Pune University

Abstract: ***In the modern IT environment , the number of cloud based applications are exponentially increasing. The underlying cloud network should sustain the increasing complexity ,and the demand for scalability and elasticity, The performance of the cloud network is the major concern in the modern data center from sociability perspective. This paper attempts to capture the survey of different technologies and algorithm used to for virtual machine placement that optimizes the cloud network.***

Keywords: Cloud, Network optimization, Virtual Machine , Container, Placement, Migration

1. Introduction

The placement of Virtual machine is the process of finding the most suitable compute host for the virtual machine . It involves classifying the underlying hardware and network and resources requirements along with anticipated utilization of resources and the placement target. The placement target can either be optimizing the usage of available resources or it can be minimizing of power consumption by shutting down few servers temporarily. The virtual machine placement algorithms are designed to meet the above goals or targets. In this paper , we are primarily focus on the optimizing the underlying cloud network used for data transfer among the virtual machines. Current data centers are built of a huge number of networked servers that are virtualized to give computing resources to a large number of users. Data centers can not properly sustain and support the performance demands of many critical applications without an enough network infrastructure. The comparative analysis of different schemes for optimizing the virtual machine placement and the application of each scheme is discussed in the rest of paper. We analyze MAPLE [8] , NETDEO[2], TVMPP[6] schemes which are mainly used for network aware virtual machine placement

2. Network-Aware Virtual Machine Placement Schemes

2.1 NetDeo

1.1.1 Overview

The NetDeo[2] focuses on improving the better utilization of the existing network design and infrastructure .It does not change the existing network architecture and routing protocol intact. Instead, it aims at reducing network bandwidth requirement by optimizing placement of VMs in the cloud. This technique has lower up-front cost and immediate applicability. This scheme addresses the following issue in the cloud network which are not addressed by others schemes.

- **Feasiblity:** It finds the all the possible virtual machine placement plans. Each plan has number of migration associated with it. The cost of the plan is decided based on the number of migrations required. It finds the placement plan that has less cost
- **Felixibility**: Even though the placement plan is optimal, it is not possible for the cloud administrator to choose the optimal plan because of the certain practical concerns. For example, the customer would not want to have their VM placed on the host that do not have required configuration to run their application. I n this case cloud administrator choose the sub optimal plan for virtual machine placement
- **Expandability**: The cloud network evolves over the period that requires administrator to opt for upgrading server and network capacity.

Moreover, in most of the cases, better cloud optimization solution involving upgrading of only a few resources The sets of servers and switches to be upgraded will be a big concern here. The NetDEO scheme addresses this issue by by employing a swarm intelligence [13] optimization algorithm which is based on modified simulated annealing [14].

1.1.2 Working

The NETDEO working consists of 4 steps as explained below

Step 1: Find the virtual machine to migrated from current to another host

Step 2:Iterate over all neighboring hosts and find the suitable target host for VM migration

Step3:Check if the performance goal is reached by this migration action. If not continue Step2

Step4: Complete the migration

1.1.3 Advantages

1) Applicable in the dynamic environment where the compute hosts are getting added and removed from the environment very frequently
2) Continues and incremental optimization of the cloud network
3) Performs good in Tree[10][11] and FatTree [12] network topology

1.1.4 Disadvantages

1) The traffic agent needs to be installed on the all compute host that keep on sending the traffic information for that particular host. Its very difficult to install and maintain the traffic agent if the number of hosts in the environ-

ment are very huge
2) Does not perform well in Bcube [9] topology
3) Performance degrades when number of hosts are increased

1.2 MAPLE

1.2.1 Overview

A MAPLE[8] is a network-aware Virtual Machine placement scheme that uses estimate of the effective bandwidth required between compute hosts to ensure that the cloud network performs within targets specified in the SLA for the customer application. It is able to allocate network resources in a in order to make perfect balance between efficiency of resource utilization and the performance requirement.

The MAPLE is designed provide a network-aware VM placement policy in which VMs within an predefined set that need to be launched or migrated on different servers are placed in order to ensure that the effective bandwidth available on the network path is adequate. The effective bandwidth as the ―*minimum bandwidth required to transfer data from source to destination that obeys specified QoS goals*.‖ The MAPLE require neither the a prior reservation of bandwidth nor the solution of traffic control mechanisms in server hypervisors. Once a set of VM is placed, they are enabled to reach their peak throughput. It is based on the use of continuously computed estimates of effective bandwidth on the network paths. This approach allows the cloud administrator to specify QoS goal for hosted applications in terms of response delay ensuring that network bandwidth is utilized efficiently. The MAPLE accomplishes the following objectives:

1) provisioning of predictable network performance to customers VM ensembles,
2) optimal allocation of network and compute resources, and
3) satisfaction QoS

1.2.2 Working

The MAPLE system composed of following 2 main components

A. Estimated Bandwidth Agent: Estimated Bandwidth Agents are installed and configured on all the servers on which MAPLE can launch virtual machines. The EB agent is responsible for sending the traffic information from the server to the MAPPLE controller using utilities like *Wireshark*. The MAPPLE controller uses this traffic information to estimate effective bandwidth. The effective bandwidth for the QoS goals(s) specified by the MAPLE controller is estimated for each network path whenever the MAPLE controller asks for effective bandwidth information

B. MAPLE Controller: The MAPLE controller is the virtual machine placement engine that handles requests for new VM ensemble placement. It decides if the request can be accepted and perform the VM placement. It consists of following three functional components.

1) Request Pre-processor: It receives VM placement requests and small number of QoS classes offered by the cloud provider. These QoS goals are mentioned in terms of packet delays instead of overall throughput levels. The VM ensemble placement requests prescribes a architecture of VMs that consists of an application , Operating system and data rates between VMs

2) Residual Bandwidth Estimator: This component manages the EB Agents installed on the compute hosts under the environment of the MAPLE system. Whenever there is a new VM ensemble placement request , the Residual Bandwidth Estimator requests a number of servers for their effective bandwidth estimate. The multiple options are possible to decide which servers are queried.

3) VM Placement: This component takes pre-processed VM ensemble placement requests as an input. It queries the Residual Bandwidth Estimator to give the set of candidate servers for VM placement and the estimates of residual bandwidth available on the links of those servers. It then runs the MAPLE network-aware VM placement algorithm.

1.2.3 Advantages

1) Good performance for deploying multiple VM at a time
2) Less QoS violation as compared to NetDEO[2] and Oktupus[7]

1.2.4 Disadvantages

1) Does not perform very good in dynamic environment where the compute host are upgraded very frequently
2) Applicable only for tree topology.

1.3 Oktopus

1.3.1 Overview

This Oktopus[7] is applicable for multi-tenent cloud provider that accepts the network bandwidth requirement from the tenant and try to allocate the required network resources while deploying the tenet application in the cloud. The tenet specifies the network requirement as ―Virtual Network‖ . It provides the abstraction of the virtual network by which it determines the trade-off between the network guarantees offered to tenant and the cloud provider's revenue.

The Oktopus extends the abstract interface to tenant so that tenant can specify the network requirements in terms of ―Virtual Network ―. The virtual network interface is guided by two design goals

Tenant sustainability : The tenant application should perform as per the requirement mentioned in virtual network

Provider's Fexilibility: The cloud provider should be able to map the multiple virtual networks to the underlying physical network and able to utilize the physical network at optimum level. It allows the sharing the network among the multiple tenants

1.3.2 Advantages

1) Virtual Network allows to specify the QoS requirement
2) Physical Network sharing ratio is increased in multi—tenant environment

1.1.1 Disadvantages

1. Not applicable for dynamic environment where the infrastructure is continuously upgraded
2. Does not perform VM migration

1.2 Traffic Aware Virtual Machine Placement Problem(TVMPP)

1.2.1 Overview

The TVMPP[6] is a network performance problem. The traffic matrix among the virtual machines and the cost matrix among the compute host machines is considered as the input for this problem. The output of this algorithm is the optimal solution that suggests which host the VMs should be placed in order to optimize the cloud network. The aggregate traffic rates dictated by every network device like switches and router. The TVMPP is NP-hard problem and propose a heuristic approach to solve the TVMPP efficiently for large environment. The algorithm follows a novel two-tier approach: it first makes partitions of VMs and hosts into clusters. Then it finds matching VMs and hosts within the cluster and subsequently at individual level. The TVMPP address following issues

1) The scalability issue of cloud networks with network-aware virtual machine placement.
2) Analyze the impact of cloud network architectures and traffic traces on the scalability gains achieved by network-aware VM placement.
3) Measure traffic patterns in the cloud environments, and use the information to launch new virtual machine and the migration

1.2.2 Advantages

1)Good performance in varying traffic condition
2)Bcube topology is benefited more with TVMPP

1.2.3 Disadvantages

1) Worst performance in tree topology
2) Not applicable for dynamic environment where the infrastructure is continuously upgraded

1.3 Hiefer

1.3.1 Overview

The Hiefer[1] is applicable for providing the predicable performance in the heterogeneous environment especially in Infrastructure-as-a-Service (IaaS). However, providing predictable guarantee for tenant applications is becoming more and more challenging in IaaS clouds. The hardware heterogeneity and performance hinderance within the same type of cloud, brings substantial performance variation to tenant applications. This discourages tenants to move their performance sensitive services to the IaaS based cloud. Hifer is designed to tackle this issue by providing the VM provisioning framework for tenant applications to be deployed in the heterogeneous cloud. It anticipate the performance of the applications using measured resource utilization and acquiring VM interference. Heifer provisions the new VM instances to good-performing hardware type to achieve predictable performance for tenant applications, by exploring the infrastructure heterogeneity.

1.3.2 Advantages

1) Good performance in the heterogeneous environment
2) Compatible with IaaS

1.3.3 Disadvantages

1) Not applicable in PaaS and SaaS
2) Does not perform well in dynamic environment

3. Conclusion

In this paper , we have analyzed different scheme and algorithm applicable for network-aware virtual machine placement in the cloud that give predicable performance for tenant application. Among the different schemes discussed , the NETDEO looks more promising as it handles the dynamic changes in the cloud environment and performs better in Tree Topology which is mostly used in the modern data centers

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