Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.47750/jptcp.2023.30.15.038

An Optimum Apparent-Integrated Virtual Network Embedding Algorithm In Cloud Computing Data Center Network

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Submitted: 11 April 2023; Accepted: 10 May 2023; Published: 20 June 2023

ABSTRACT
The cloud computing model is enabling innovative and disruptive services by allowing industries to lease/rent computing , storage and network resources from cloud service providers.(ex: google cloud platform,IBM cloud platform) .The insertion of virtual network in the existing physical network is called virtual network embedding problem(VNE). The major challenges faced by cloud service providers (CSP) are unexpected failure of services which have direct impact on Quality of Service, energy consumption, service level agreement violation and huge revenue loss. To overcome this, an optimum apparent –integrated virtual network embedding algorithm is used in cloud computing fat tree data center network .The intellectual property of the proposed algorithm is that the virtual machines are embedded to different physical machines in both consolidated and distributed manner. In other words, the proposed algorithm executed in multiple physical servers in order to concurrently mapping virtual resources of a virtual network and reduces the resource-mapping time and also increase QoS of services provided by CSP

Keywords: *cloud service providers, virtual network embedding, quality of service, resource mapping*

INTRODUCTION
Cloud computing is a virtual platform where the desired computing resources such as applications, servers(physical and virtual servers),data storage, development tools, networking capabilities,etc needed by the customer are delivered via internet by the remote data centers hosted by cloud service providers (CSP)like IBM cloud, Amazon cloud,etc. The CSP give these resources available for a rent/lease and the customer has to pay as per usage. Virtualization plays a major role in cloud computing environment.

It virtualize IT infrastructure like servers, operating system software, networking and more are abstracted using special software so that it can be shared irrespective of physical hardware boundaries. For example one physical server can be divided into multiple virtual servers. On our everyday use, many application like Google,Gmail,Netflix or cloud file storage like Dropbox in computer or mobile device use some form of cloud computing . According to recent survey approximately 92.5% of organization using cloud today and most of them plan to use it more within next year.[10]

The major benefits of virtualization is agility, scalability and availability of computing resources. So, virtualization is the primary measure to share same physical server among multiple tenants by creating virtual version of the resources. N number of physical machines are connected to physical servers using Fat – Tree topology which is majorly used in commercial data center network. A standard fat-tree architecture is a switch centric architecture which has three vertical layers-edge, aggregate and core. A fat tree topology has k pods with each pod having k/2 edge and k/2 aggregation switches. Each pod has a link to each core via aggregation switches. Each switch in the edge layer is connected to k/2 servers.

The information about physical machines are shared to the tenants by creating multiple virtual machines and verifying with service level Agreement , privacy policies,QoS between the tenant and virtual machines i.e. IP. In virtual network multiple virtual machines are connected and cloud service providers should map their available resources to the tenants is called as Virtual Network Embedding (VNE) problem.[11]

The major issues faced by virtual network embedding algorithm are failure in the embedding link of physical machine, heavy workload and power failure which cause a major impact on reputation of cloud service providers.

To rectify this issue, an optimized apparent-integrated virtual network embedding algorithm is proposed where the algorithm is divided into two phases. In first phase, the virtual networking algorithm is installed in a dedicated server which accomplish the embedding process to all VM. In second phase, embedding process is done in a distributed manner.

RELATED WORKS

In [1] describes the data center network topologies and its impact in attaining high Data Center Network performances in terms of scalability,power consumption, throughput and traffic load balancing. So they proposed circulant Fat-Tree topology to minimize traffic congestion at core switches ,improves network latency and robustness as compared to traditional Fat-tree DCN topologies as it has bottleneck issues in various stages of switch.This paper [2] reviews load balancing techniques in software-defined data centres with the fat-tree architecture. Load balancing techniques have become smarter and more effective over the years with reductions on overhead statistical collection and improvement in the quality of service.

This paper[3] formulates the cooperative VNE problem and proposes a distance-based

VNE method to solve the problem efficiently. The proposed VNE method can perform virtual node mapping precisely on the basis of the mapping results of multiple cooperating virtual nodes to the shared substrate nodes. The proposed method can balance the utilization of substrate resources by exploiting the modified distances on the virtual network and substrate network.

Simulation results reveal that the proposed method can reduce the total amount of substrate resources required for cooperative VNE in cases of unrestricted substrate resources and achieve a

high success rate for cooperative VNE under the condition where substrate resources are restrict

discuss the performance modeling methods with a particular focus on their accuracy and cost, and compare the overhead mitigation techniques by identifying their effectiveness and implementation complexity. With the obtained insights into the pros and cons of each existing solution, we further bring forth future research challenges pertinent to the modeling methods and mitigation techniques of VM performance overhead in the IaaS cloud.[7]

Problem formulation

The work of the cloud service providers to embed multiple virtual machines to the set of physical machines under the network topology. The network topology is characterized as Fat-tree topology. Eventhough, physical machines used in the network topology are heterogeneous , the resource requirements including computing resources and network demand of virtual machines and the virtual links are assumed to be static and will not change. Fat tree topology[fig 1] comprises of three switches such as core switch,aggregation switch and edge switch. Let k be the number of ports available at each switch. The number of core switches are $(k/2)^2$. the total number of aggregation and edge switches are k/2. The number of servers that fat tree topology supports are $k^3/4$. The overall number of switches supported by this network are $5k^2/4$[3]. The number of physical machines underlined in this network are $k^3/4$. The k ports in a switch are divided into two groups of k 2 ports. One group is used to connect to the upper layer switches and another group of ports is used to connect to the lower layer switches. The remaining available bandwidth at each physical machine is calculated in three categories. 1.The remaining minimum bandwidth available between the physical machine and edge switch. 2. The remaining available minimum bandwidth between the edge switch and aggregation switch. 3. The remaining available minimum bandwidth between the aggregation switch and core switch. The workload of each physical machine in [8] virtual network can be calculated as the ratio between the amount of physical computing resources allocated to other virtual networks and its maximum resource capacity. The required bandwidth of each virtual machine can be calculated by the summation of the bandwidth required by the nearby virtual links.

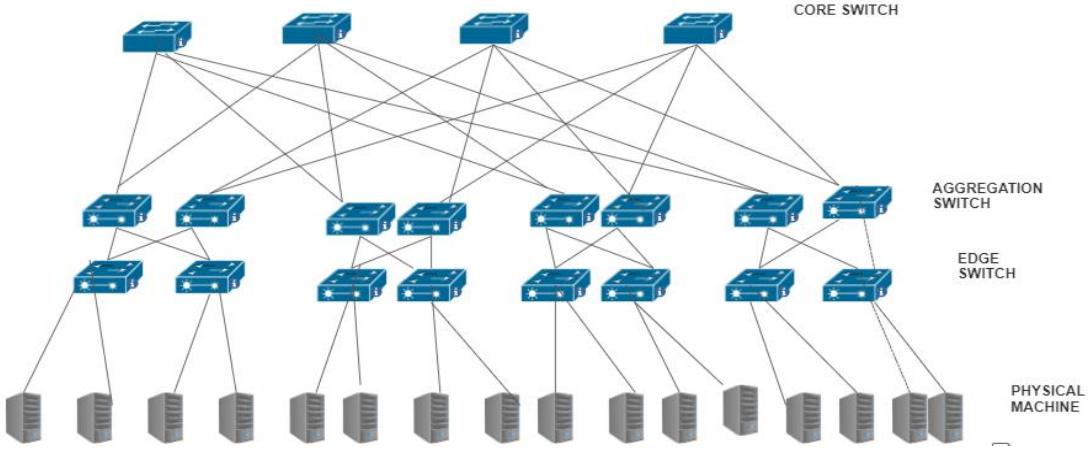

FIG 1: Fat Tree Topology

Proposed Virtual network Embedding Algorithm

the objective of the proposed virtual network Embedding Algorithm is to reduce the impact of resource failure in virtual networks.It can be achieved by using An Optimum Apparent-Integrated Virtual Network Embedding Algorithm In Cloud Computing Data Center Network using Fat Tree Topology.As per this algorithm, get an virtual network embedding (VNE) request as input the algorithm will split into two phases where in the first phase PM group formation stage and next is VM selection stage.

Pm Group Formation Stage(Pm-Gf)

A collection of physical machine forms a group. The entire global information about the data center network including the number of server resources such as CPUs,memory and storage availability,bandwidth information in each link.It also gather information regarding virtual link including computing resource requirement such as memory,CPU and the bandwidth.

The bandwidth of each virtual machine=∑ bandwidth required in each virtual link

The remaining available bandwidth at each physical machine=Min(remaining bandwidth available at each link from PM to core switches

As per PM group formation algorithm-1 receives one virtual network embedding request one at a time. Intialise P ,V with set of all physical and virtual machines available. The maximum bandwidth requirement is calculated in lines 4-7 considering the resource requirement like CPU , Memory of each virtual machine. The remaining available bandwidth at each PM is compared with the maximum bandwidth requirement in order to remove physical machines with inadequate resources (line 8). The set P_1 has the list of physical machines that are eligible to provide enough network bandwidth to all the virtual machines. Likewise P_2 and P_3 are used to collect the list of physical machines that are eligible to provide required resources in line 9,10. In line 10 generate a sorted list of physical machines is obtained by the intersection of the three sets. From the resultant sorted list of physical machines n*c numbers of physical machines are chosen for the current virtual network where c is the physical machine group size, n represents the number of virtual machines present in the current virtual network

ALGORITHM-1 PM GROUP FORMATION ALGORITHM

1. Initialise: P={set of all PMs};
2. V={set of all VMs};
3. n=|V|
4. Mem_max=max(mem(α_i)) for all $1 \leq i \leq n$
5. CPU_max=max(cpu(α_i)) for all $1 \leq i \leq n$
6. New_α_i =$\sum_j^n \alpha_{ij}$ i≠j
7. New_VN_max= max(New_α_i) for all $1 \leq i \leq n$
8. P_1={p_i|$\beta_i \geq$ New_VN_max, for all $p_i \in P$ }
9. P_2={p_i|mem_$\beta_i \geq$ New_VN_max_mem, for all $p_i \in P$ }
10. P_3={p_i|cpu_$\beta_i \geq$ New_VN_max_cpu, for all $p_i \in P$ }
11. Resultant = sort { $P_1 \cap P_2 \cap P_3$} in ascending order
12. Group_list={set of n*c number of PMs from Resultant};

Vm Selection Algorithm

The inputs for the virtual machine selection algorithm-2 are resource requirement of virtual machine Resource availability of all PMs , Workload of all PMs,Failure probability of all PMs. The algorithm begins by getting the unique machine ID of the physical machine where the algorithm is running(line 3). P_id represents the physical machine where the algorithm is running. Each physical machine has a set of edge layer (line 5). Since the set of edge layer neighbor physical machines does not include the physical machine another set is formed with union operation for the set of PE and PM itself(line 6). The failure of all physical machines that are connected to the same edge switch are compared to find the leader PM. At line 7 the physical machine with least failure probability value is chosen as leader. The leader physical calculates the overall failure probability (line 13).it helps to compare the failure probability of other physical machines with the leader physical machine. Those physical machine that does not satisfy the leadership condition will wait and obey the instruction from their leaders.(line 11).

If the physical machine group has multiple edge switches then there is a possibility of multiple leader physical machines. So each edge switch there will be single leader physical machine which further each leader physical machines can have set of other leaders that are connected to different edge switches. The leader physical machine SP is selected from the set of set of leaders and their corresponding overall failure probability value(line 15). The leader physical machine SP will call VM selection function at line 21. It will physical machine to pick out suitable virtual machine without any conflict with other physical machines.

ALGORITHM 2 VM SELECTION ALGORITHM

Input :resource requirement of VN
Resource availability of all PMs
Workload of all PMs
Failure probability of all PMs

1. **Initialization**
2. V={set of VMs belong to current VN};
3. ID: unique id of PM where the algorithm is running
4. P_id=current PM where the algorithm is running
5. Form the set PE_c(p_id)
6. PE={p_id ∪ PE_c(p_id)}
7. PL= min(fp(p_i)) for all values of i
8. If PL=P_id then
9. Goto Line 13
10. Else
11. Wait for further instructions from PL
12. End
13. FP(PL)=$\sum_{for\ all\ pm}$ FP(p_i)
14. Compare with other PL
15. SP= leader PM with minimum FP value calculated in step 13
16. If SP=P_id then
17. Goto line 21
18. Else
19. Wait for instruction from SP
20. End
21. Status= selection(V);
22. If status≠ allembedded then
23. Foreach PL in PE_a (p_ID) do
24. Remove VMs that are already allocated;
25. Send instruction to PL to execute selection(V)
26. If V= empty then
27. Abort
28. End
29. End
30. Foreach PL in PE_c (P_ID) do
31. Remove VMs that are already allocated
32. Send instruction to PM pl to execute selection(V)
33. If V=empty then
34. Abort
35. End
36. End
37. End

Selection Algorithm

The algorithm 3 is used by physical machines to choose one or more than one suitable virtual machines independently from the given set of virtual machines without any communication with other physical machines. The physical machine with minimum workload is selected(line 4). The virtual machine pair is selected with maximum bandwidth demand and maximum resource requirements(line 6). From the selected virtual machine pair the virtual machine with maximum resource requirement is selected by the physical machine(line 8).likewise, the remaining virtual machines will select the physical machines based on their remaining resources (line 12-14) . the selection procedure will continue until available resources are mapped to the virtual machine. All physical machines follow the same procedure in parallel manner.

ALGORITHM 3 SELECTION ALGORITHM

1. If P_ID=PL then
2. Send instruction to all PM that belong to PE to execute selection(V)
3. End
4. P_c =min(p_i) /* choose PM with minimum load from PE */
5. Select VM pair(v1,v2) with maximum bandwidth demand
6. Res_req1= VM with maximum resource requirement between VM v1 and v2
7. If $\beta_c \geq \alpha_a$ then
8. Assign Res_req1= PM P_c
9. Else
10. Goto line 4
11. End
12. Res_req2= VM with minimum resource requirement between VM v1 and v2
13. If $\beta_c \geq \alpha_a$ then
14. Assign Res_req2= PM P_c
15. Else
16. Goto line 4
17. End
18. If V set is empty then
19. Abort
20. Else
21. Repeat from line 5
22. End

The proposed Apparent-Integrated Virtual Network Embedding Algorithm is suitable only for Fat-Tree network topology where multiple layers of the core,aggregation and edge layer switches are used to connect a large numbers of physical servers.according to this algorithm , the calculation of the number of neighboring PMs plays a vital role in the embedding process. As per discussed, the proposed apparent –integrated virtual network embedding algorithm is applicable for Fat-Tree network topology , so it has to be modified to other network topologies also. Further scaling the proposed algorithm to a large number of physical machines, the embedding time will increase due to overhead in communication during execution of the algorithm inspite of different network topology.

Performance Evaluation

In this section we evaluate the performance of proposed apparent –integrated virtual network embedding algorithm against two popular centralized virtual network embedding algorithm VNE-DCC [node degree and cluster coefficient) and VIE-SR(sequential rounding) [12][13]considering the performance metrics such as acceptance ratio ,average number of required resources and embedding time. Acceptance ratio is defined as the ratio between the number of virtual networks accepted and the number of virtual networks received by the cloud service providers from users. Average number of required resources refers to as the number of physical machines and links required as per virtual network. Embedding time is the time taken by the algorithm to carry out the embedding procedure. Based on the above mentioned performance –metrics , the following results are derived. Fig [2][3] shows the graphical analysis of number of virtual networks versus number of physical machines and calculate the average number of resource required and acceptance ratio

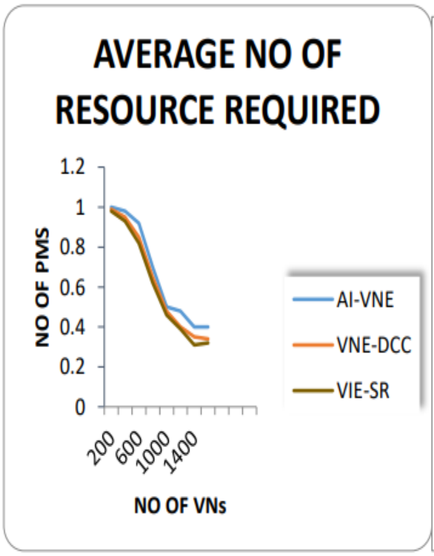

Fig 2: Average number of resource required

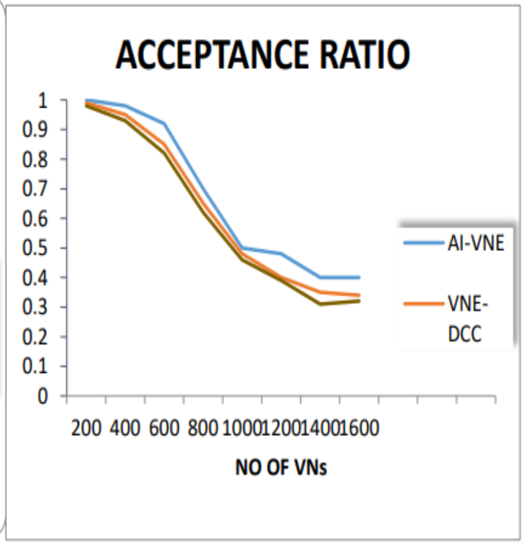

Fig 3: Acceptance ratio

using AI-VNE and also referencing the results of VNE-DCC and VIE-SR [12][13] and the performance of AI-VNE is high compared to the other models

CONCLUSION

In the proposed model, VNs are mapped onto the existing physical network in two-staged apparent-integrated manner .Multiple VMs are allowed to be embedded onto the single PM. Further,the VMs are mapped onto a set of PMs with minimum distance. The PMs with minimum failure probability are given higher preference to host the VMs. This helps us achieve the goal to minimize the virtual resource failure probability. In additon, extensive simulations are performed and our simulation results are compared with other similar algorithms[12][13]. The simulation results indicate the superior strengths of our AI-VNE over other algorithms in terms of acceptance ratio, minimization of required physical resource, embedding time and VN failure probability. For future work, we planned to implement the proposed AI-VNE solution in real cloud environment in order to verify and improve the simulation results under circulant Fat tree topology to reduce the bottlenecks at the switches

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