Virtual Machine Placement in Cloud Computing: Challenges, Research Gaps, and Future

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Abstract

Cloud computing provides various types of services to users. The goal of virtual machine placement (VMP) is to map the best physical machine to a virtual machine. With the help of Virtual Machine Placement, we can reduce cost, maximize resource utilization, reduced energy consumption of data centers in cloud environments. The focus of Virtual Machine Placement is to saving of power, quality of service. In this paper, we have reviewed various placements techniques used in cloud computing. At last, we have also studied various challenges for virtual machine placement in cloud computing. The main motive of various types of Virtual Machine Placement algorithms have to reduced energy consumption and minimize cost by maximizing utilization of various resources in the cloud platform. For further study, the researcher should focus on these challenges for the best virtual machine placement in a cloud environment. In this paper, we critically examine the techniques, challenges, and research gaps in virtual placements in cotext with Cloud Computing. Cloud computing, placement of virtual machines becomes major problems. For finding the solution to the problem we can use the various virtual machine placement algorithms. The main motive is to reduce consumption of energy, maximum resource utilization, minimizing cost factors used for virtual to the physical machine mapping in the cloud environment**.** For selecting the best algorithm various optimization methods are used. With these different optimization methods, we can analyze different algorithms. There is a great scope of improvement in existing systems of virtual placements to make them more energy-efficient, more reliable, and fault-tolerant. Redundancy in cloud downloading can be made more intelligent and minimized for duplicate data while downloading and uploading.

Keyword*:* Virtual Machine(VM), Virtual Machine Placement, Data Center, Cloud Computing, Quality of Service, Bin Packing

1.Introduction

In this modern scenario, cloud computing uses pay per usage method. Different types of service models such as Infrastructure as a Service (IAAS), Platform as a Service(PAAS), Software as a Service(SAAS) are used in cloud platforms. Virtualization uses these three service models like Infrastructure, Platform, and Software. The main responsibility of cloud providers is to manage the virtual machines that are implemented on physical machines.

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1.1 **Virtualization:** virtualization in cloud computing means creating a virtual environment that does not exist in reality. It provides services for efficient use of resources (hardware and software)[12] With these virtualization methods, numbers of users can share the same hardware/software resources. Hypervisor acts as a virtual machine monitor (VMM) and it is used for virtualization. Virtual Machine migration is one of the important features of virtualization. For performing virtual machine migration the task efficiency, load balancing, resource utilization, energy efficiency, and maintenance of the system should be considered. Virtual Machine migration is further categorized into live or nonlive migrations.

1.1.1 Live Migration: In Live Migration, the status of CPU, Data storage, and memory are transferred from one machine to another machine. For measuring the optimization performance of the network, we can use a performance matrix with parameters such as service downtime, migration slot, and amount of data transferred.

1.1.2 Non-Live Migration: In Non-Live Migration, stop the application service, perform the migration. We can use three steps such as Pause, Copy and Resume.

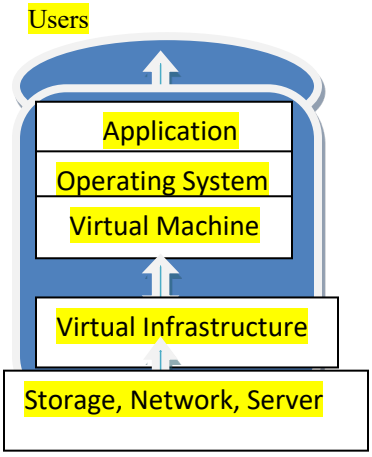

Fig. 1: Virtualization Mechanism in Cloud Computing.

Advantages of Virtualization[12]

Resource Sharing: The virtualization used for the utilization of various resources used in cloud computing.

Security: virtualization increased security with the protection of integrity on virtual machines.

1.2 Virtual Machine Placement: In this type of placement, we can allocate the virtual machine onto the physical machine. The main motive for virtual machine placement is to reduce energy consumption by data centers. By decreasing the number of Virtual Machine migrations, we can reduce energy, cost, and traffic flow on data centers [3]. Virtual Machine Placement is an important process for finding the most relevant physical machine or server for hosting virtual machines in a cloud environment. For selecting relevant physical machines, the virtual machine placement has to improve the utilization of various resources, quality of services, and energy efficiency in the cloud.

1.3 Classification of Virtual Machine Placement Algorithms

With the help of various parameters, the Virtual Machine placement maps the physical machine to a dynamic machine [5]. The following diagram shows the various types of classification techniques and the required parameters like goal dependence, migration necessity [14].

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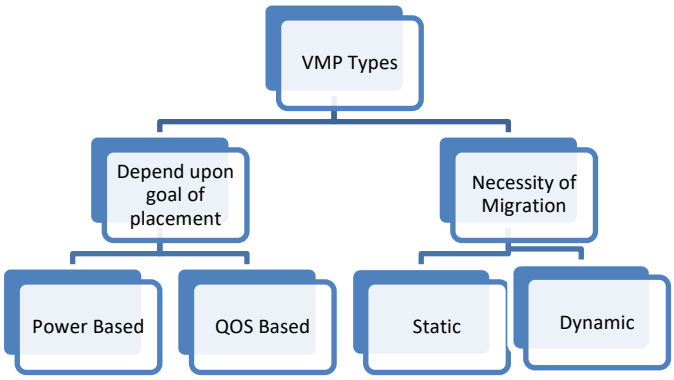

Fig 2: Various Types of Virtual Machine Placement

1.3.1. Classification of VM placement Algorithm depends upon the goal of Placement

1.3.1.1 Power Based VM Placement

1.3.1.2. Quality of Service Based VM Placement

1.3.2. Classification of VM placement Algorithms (based upon the necessity of migration): This type of algorithm has been used for transforming of virtual machines on physical machines. It is further divided into two parts:-

1.3.2.1.Static Virtual Machine Placement: It carries out offline calculation. This type of algorithm does not consider state (Virtual Machine or Physical Machine) or request the accepted rate of the user.

1.3.2.2.Dynamic Virtual Machine Placement: It is an Optimum method for mapping Virtual Machine with minimum cost parameters. It uses an online virtual machine placement algorithm and includes migrations. It uses the rate of user query generation and state of mapping virtual machine with a physical machine.

The two main subcategories of dynamic virtual machine placement algorithms are following.

1.3.2.2.1. Proactive Virtual Machine Placement:- Before the system reaches a specific condition, for its initial placement, the change of virtual machine to physical machine occurred.

1.3.2.2.2. Reactive Virtual Machine Placement:- When the system reach the specific state, then change to initial placement occurred.

1.4 Virtual Machine Placement Algorithms

For maximum utilization of the server, dynamic virtual machine placement algorithms are used. The various approach types have been used for virtual machine placement in cloud environments [16][22-25].

1.4.1.Constraint Based Approach: In this type of approach, the client uses the state of constraints and finds the solution with help of these constraints. The constraints may be a relationship between variables. These approaches are based on Logic programming. For finding the relevant solution we required constraints solving techniques. At the time of Virtual Machine Placement, some constraints are considered such as capacity, placement, Quality of service (QoS). This type of programming is used where inputs are known (demand of Virtual Machine).

1.4.1.1.Capacity Constraints: Constraints relevant to Physical Machine such as CPU, Memory, and sum of various resource utilization by all Virtual Machine in the host is always smaller or equal to total utilization of the physical machine.

1.4.1.2.Placement Constraints: Virtual Machine is placed on the available host.

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1.4.1.3.Quality of Service (QOS) Constraints: For placement of a Virtual Machine some values like throughput, availability, response time, efficiency are considered.

1.4.2.Stochastic Integer Programming (SIP): In the field of mathematic, the SIP has been used for the optimization of problems with help of Known and Unknown factors. The objective is to find the solution which applies to the data set values**.** With unknown data, SIP is used for the optimized task. It is used to find a relevant host which uses less energy and low wastage of resources[26-29].

1.4.3.Bin Packing: Bin packing used for mapped of various virtual machines on physical machines. In this, the individual physical machine can be considered as a bin with resource capacity. The virtual machine acts as an object to be packed into a bin. For maximizing utilization of total numbers of bins, the bin packing algorithm has been using for mapped objects with bins. In this, the number of virtual machines (small items) is placed on physical machines. The objective behind this is to minimize the item to be packed in large (Physical Machine) space.

1.4.4.Genetic Algorithm: When the objective function changes dynamically, the Genetic Algorithm is used. It is used for static virtual machine placement where the demand for resources does not change over time.

TABLE 1: Advantages and Disadvantages of VMP Techniques

Algorithms	Advantages	Disadvantages
Constraint Programming	At Run time, Change in Global Utility Function can be made.	Increase Response duration
Stochastic Integer Programming	Not necessary of recomputation	Do not Perform Actual Mapping between VM to PMs.
Bin Packing	In Dynamic Allocation, The PM becomes to half.	Solution Space is not checked so no relevant result.
Genetic Algorithm	Work well irrespective of the number of Constraints.	Limited on several generations.

1.5 Performance Matrix Based on Parameters

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For analysis of various parameters used in virtual machine placement algorithms, different objectives should be taken under consideration such as

a. Hardware Resources
b. Network Traffic in the data center
c. Cost

Hardware Resources: Placement of Virtual Machine on Physical Machine in Cloud environment is based on maximum utilization of various hardware resources such as Processor, Memory, Input/ Output.

Network Traffic: the main motive is to reduce the network traffic for avoiding congestion. For this task, we can use parameters like Traffic between Physical Machine, Traffic between Virtual Machine, Distance between Virtual Machines, Minimize data transfer time.

Cost: we can consider cost-saving while using the Quality of Service(QOS) of Cloud services. For this cost function, we can use various costs such as Virtual Machine Cost, Physical Machine Cost, Data Center Cost, Cooling Cost, etc.

2. Challenges In Virtual Machine Placement

The objectives of various Virtual Machine Placements are following [13]

i) Reduce Network Traffic
ii) Avoid Network Congestion in Cloud Data Center
iii) Decreasing Cost Analysis
iv) Improve Security
v) Improve Performance
vi) Minimize the number of active servers

2. Optimization Methods

Optimizations mean finding the exact solution to a problem. Various optimization methods are used to solve the dynamic virtual machine placement algorithms. For server consideration, various parameters are used for decision making, and methods are used to map virtual machines onto physical machines with quality as a factor. The optimization techniques are classified as

2.*1 Approximation*: This technique has been used to find the approximate location of a virtual machine.

Exact: Exact Solution for finding a location

Exact Solution: Optimal solution for a finite set of time. For this task, we consider a mathematical approach for mapping Virtual Machine to Physical Machine.

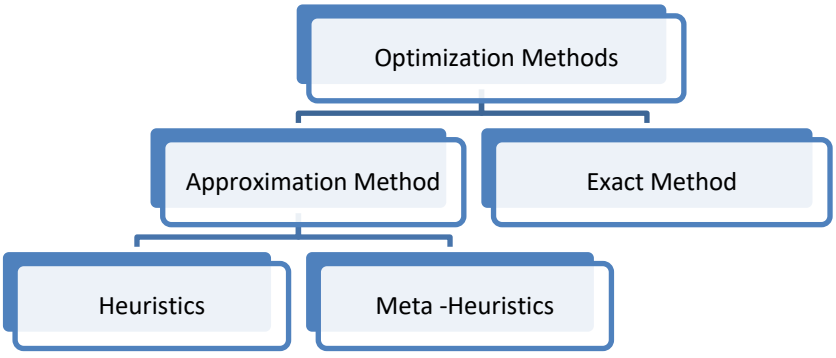

Fig. 3: Types of Optimization

2.2 Heuristic Method: It is a dependent method, which doesn't describe the optimal solution to any problem.

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Meta Heuristic Method: It is an independent technique and which tries for finding optimal results of a problem.

TABLE 2: Analysis of various Types of Algorithms with solutions

Algorithms	Heuristics	Meta Heuristics	Exact
Constraint Programming	×	×	√
SIP	×	×	√
Bin Packing	√	×	×
Genetic Algorithm	×	√	×

3.Research Gaps :

After studying the various review papers on VM Placement Algorithms, the different types of problems exist. To overcome these types of problems in Virtual Machine placement algorithms various parameters like energy efficiency, traffic of network, cost, are used for further enhancements.

Some research gaps are as follows:

- Increase energy efficiency
- Cost Optimization
- Network Bandwidth
- Migration Time
- Operation Overhead
- Self Adaptive Load Balancing of Dynamic Virtual Machine
- Fault Tolerance
- Resource Utilization

4. Conclusion:

In Cloud computing, the placement of virtual machines becomes a major problem. For finding the solution to the problem we can use the various virtual machine placement algorithms. The main motive is to reduce consumption of energy, maximum resource utilization, minimizing cost factors used for virtual to the physical machine mapping in a cloud environment**.** For selecting the best algorithm various optimization methods are used. With these different optimization methods, we can analyze different algorithms. There is a great scope of improvement in existing systems of virtual placements to make them more energy-efficient, more reliable, and fault-tolerant. Redundancy in cloud downloading can be made more intelligent and minimized for duplicate data while downloading a Bin Packing d uploading.

5. Challenges And Future Scope:

In this review paper, the various challenges have been listed such as energy efficiency, cost optimization, maximum resource utilization, network bandwidth, and migration time. In future work, the research scholars will study the above parameters for VM placement in cloud computing environments.

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