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Virtual Machine Optimization using Nature Inspired Algorithms

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Abstract: The piller of cloud computing is the virtualization technology. Virtualization is a technique to share a physical machines resources into many virtual machines.

With the growth in the usage of VMs, VM placement and optimization is the need of the hour. It reduces the operating cost and increases physical machine utilization in a data center. The prime requirement is to reduce the number of active physical machines and increase the number of virtual machines per physical machine without compromising the data quality and data security. This significantly reduces power consumption and cloud operation costs.

This paper provides a comprehensive survey on the algorithms proposed for optimal VM placement and selection in a cloud environment. The algorithms include Ant colony optimizition(ACO), Particle Swarm Optimization(PSO), Genetic Algorithm(GA), Flower Pollination Algorithm(FPA), Fruit Fly Algorithm(FOA), Honey Bee Algorithm9BA). These are a class of nature inspired algorithms which are found useful in selecting and allocating VM resources in a cloud computing environment which requires highly efficient and scalable solutions for dynamically allocating computing resources in the cloud

Keywords: Optimization, VM Placement, Ant Colony Optimization, Parallel Swarm Optimization, Nature Inspired algorithm

I. INTRODUCTION

Optimization is ubiquitous and spontaneous process that forms an integral part of our day-to-day life. In the most basic sense, it can be defined as an art of selecting the best alternative among a given set of options. The cloud computing environment provides facility to use computing resources on a need basis for the users. The shared resources needs to be managed efficiently which requires scalable and efficient scheduling and allocation of computing resources. The cloud computing environment is based on IaaS (infrastructure service as a model).

The resources include virtual mechines which are dynamically allocated to the users and this involves finding the phisical hosts on which VMs can be placed as well as migration of VMs across hosts on need basis. Various nature inspired algorithms can be used to achieve this purpose.

Optimization helps to completely utilize all the resources of a currently running physical machine. Optimization helps in reducing the power consumption thereby improving the green computing. In real life situations, there will be many constrains for optimizing the cloud centre. Maximizing the efficiency of the cloud centre and minimizing the undesired factors is really challenging task to solve. Optimization is a trial and error method.

Many new algorithms will be proposed and their results are tested against the desired metrics and the successful ones are continuously modified to get the better results. Broadly we can classify the optimization algorithms as conventional and non conventional algorithms. Much of the work is already done in the conventional algorithms but very few are proposed in non conventional algorithms.

The non conventional algorithms are primarily the Bio or Nature inspired algorithms. These nature inspired algorithms need intelligence and the AI tools are used for inducing the required intelligence into the algorithms.

It is computationally very expensive to find the optimal solutions for type of algorithms.

Therefore, the majority of proposed algorithms are mainly focusing on finding the approximate solutions for VM load balancing problem instead of optimal solutions. For this category, we classify the surveyed algorithms as three types: heuristic, meta-heuristic and hybrid algorithms.

Algorithms such as Swarm Intelligence (SI), Genetic Algorithm (GA) comes under heuristic methods, and Simulated Annealing (SA), Tabu Search (TS) and Hill Climbing comes under meta-heuristic methods.

II. LITERATURE SURVEY

This section provides insight into existing algorithms developed which can be used for optimal virtual michine selection and placement in a cloud environment.

A. (Said) Aims at scheduling in cloud computing belongs to a category of problems known as NP hard problem due to large solution space. Cloud computing consists of mapping tasks on unlimited computing resources. Nature inspired algorithms in ant colony optimization (ACO), Particle Swarm Optimization (PSO) and Gravitational Search Algorithm (GSA) which help in solving NP hard problems are used in this search. Nature inspired algorithm in the area of security to protect information associated with tasks and cloud computing.

B. (Kumar 2018) Presents a critical survey of nature clever algorithms which are used in artificial intelligence and automation in real life domains. Nature inspired algorithms is emerging area of research on algorithm based on physics and biology. This paper explains the phenomena of nature to duplicate in artificial systems. Nature inspired computing and computational intelligence will provide maximum solutions to problems and open new venue in research and development.

C. Nature with its extremely diverse, dynamic, robust and complex and fascinating phenomena is the great source of information for solving problems in computer science. Biology inspired computing has a wide field for research in particular there are great opportunities in exploring a new approach. Nature inspired algorithms are most powerful algorithms which increases the field of future generation computing (Binitha S 2012) presents a broad view of biology inspired optimization algorithms which intern increases the areas where these algorithms can be successfully applied.

D. Cloud computing needs optimal resource utilization of cloud resource which intern need certain novel scheme with enhanced dynamic resource allocation, collective control, resource management and its maximum distribution in networking and computing resources. The present trend of using virtualization in resource mobilization for data centres using machine migration techniques. (Theja and Babu 2014) Discusses proposed approaches for optimization of resources for cloud infrastructure. Virtual machines with association with physical machine can be effective solution for resource optimization by the consideration of certain increased predictive schemes, load balancing and mapping could be increasing factor in virtualization for better performance.

E. VM placement in cloud is done by focusing on objects like VM allocation time, energy consumption, SLA violation utilisation of resources etc, (Suseela and Jeyakrishnan 2014) the proposed algorithm that is multi hybrid ACO-PSO algorithm reduces the resource wastage and power consumption also provides load balancing in servers. It helps in reduction of server costs.

F. (Usmani and Singh 2016) Deals with details regarding VM placement algorithm aiming at maximum utilization to reach optimal solution minimization of power consumption. This algorithms aim at studying the workload variability and changing the demands of applications the minimization of trade of between the energy consumption and good performance by using a hybrid technique for serer energy efficiency. This is a two staged process comprising of green computing and overload avoidance.

G. VM migration is a source intensive procedure as VMs continuously demands appropriate CPU cycles, cache memory capacity and communication bandwidth. The continuous movement becomes essential in managing efficiency of data centres and to smoothen the application service. (Choudhary, Govil et al. 2017) Deals with the problem faced in VM migration as they have to be migrated while they are continuously running this is possible only if VMs are migrated with zero down time. This identifies the types of content that need to be migrated like CPU state, memory content and storage content. This discusses pre-copy, post copy and hybrid technique of VM migration. VM migration approaches are divided into two broad categories Models and Frameworks.

H. Cloud computing has attained a remarkable growth in every field it makes provisioning, scaling, maintenance of applications and serves a breeze. (Rani and Bhardwaj 2017) Focuses on task scheduling ant colony optimization genetic algorithm PSO and GSA. This survey deals with task scheduling in cloud computing based on current information and sources to build a good mapping relationship between task and resources. It clearly compares the ant colony optimization with other techniques to prove the former as better in comparison.

I. The main goal of (Challita, Paraiso et al. 2017) is to provide a understanding of existing approaches and algorithms to ensure better VM placement in the contest of cloud computing and identification of future systems. The state of art of VM placement optimization aims at reduction of work, power, cost and prevention of congestion of dataflow. The migration of VM requires a secure connection between source and target servers. This aims at making a way for further work to address this problem for establishing and managing better communication.

J. Cloud computing which is important development in sharing and pooling of resources over internet services is still in its infancy to achieve improvement much research is required in various directions one is scheduling the goal of scheduling is to trace appropriate resources. This belongs to a category of problem known as NP hard problem. There are no algorithms which produce optimal solution with in polynomial time to solve this problem. Meta heuristic based techniques provide some solution with in required time. Meta heuristic techniques like ACO GA and PSO and two new techniques like League Championship Algorithm (LCA) and BAT Algorithm (getting inspiration from echolocation behaviour of bats yang introduced BAT algorithm) forms these techniques(Kalra and Singh 2015). The comparative analysis of algorithm based on Meta heuristic techniques mainly compares techniques used for Meta heuristic, optimization criteria, nature of tasks and the environment in which the algorithm is implemented.

K. (Son and Buyya 2019) Proposes Priority Aware VM Allocation (PAVA) which uses network topology information to allocate VM on the host which is nearest to the requester of the resource. The priority of the task is also considered as parameter. The VMs are grouped based on the type of applications.

III. SUMMARY OF RESEARCH ON NATURE INSPIRED ALGORITHMS

1) Method 1: Ant Colony Optimization(ACO)

Author and year	Parameter used	Limitations	Advantages	conclusion
(Deng, Xu et al. 2019)	Ants, pheromone factor, heuristic factor, initial concentration, maximum iteration	Time complexity is high	Optimal for solving combinatorial problems,	best routes found by the ICMPACO
(Dorigo 1992)	Number of ants		Implements search procedure and feature subset selection	Solving complex optimisation problems and distributed control problems by observing behaviour of ant colonies
(Venkatesan and Karnan 2010)	Mel-filter bank, lenear predictive reflection coefficient, wavelet energy bands	Classification is difficult	Measures the distance between image blocks and domain blocks	Optimal solution using feature subset selection and search procedure
(Dorigo and Gambardella 1997)	Pheromone, optimal number of ants, cooperation among ants	No known limitations	Optimises the classical TSP using ACS	Explains how ant colony system(ACS) works
(Somani, Khandelwal et al. 2012)	Cost, time , migration and resource wastage		VM placement in IASS cloud	ACO may reduce the cost, response time and failed to reduce the number of migrations

Table 1: Ant colony optimizition survey

2) *Method 2:* Particle Swarm Optimization(PSO)

Nowadays the practical problems are becoming complex day by day. We need to develop such an algorithm which can successfully solve unimodel as well multimodel optimization problems. This survey presents some important developments in the field of PSO which may help the researchers and scientists to study the recent developments in this field and to propose some better versions of PSO variants.

Author and year	Parameter used	Limitations	Advantages	conclusion
(Singh and Chana 2015)	Execution time	it not consider multiple levels of QoS requirements		QoS Aware Resource Scheduling in Cloud Environment
(Dashti and Rahmani 2016)	Makespan		It more efficient for scheduling	modified PSO algorithm
(Lalwani, Sharma et al. 2019)	CPU based and GPU based strategies		Comparison between different PSO approaches	Study of variations of PSO algorithm
(Xu and Yu 2018)	contraction-expansion coefficient, wave function	Does not fully address the issue related to convergence rate and running time	Markov properties of SPSO are analyzed	convergence of SPSO is studied using martingale theory
(Selvaraj, Patan et al. 2019)	Turnaround Time, Waiting time, and CPU utilization		Efficient when compared to SPSO, GA, and DPACO models	VM selection using Swarm intelligence approach

Table 2: Particle Swarm Optimization survey

3) *Method 3:* Genetic Algorithm(GA)

Author and year	Parameter used	Limitations	Advantages	conclusion
(Mosa and Paton 2016)	energy consumption and overall SLA Violations	Qos factors are not considered	reduce response time and maximize resources utilization	Proposes VM placement for energy and SLA in clouds
(Mi, Wang et al. 2010)	CPU	Overhead of large searching spaces	Improved cpu utilization, less number of APMs	Reconfiguration searching module
(Gao, Guan et al. 2013)	CPU, network and storage	High computation time	Near optimal solution, energy efficient, resource wastage reduced	ACS meta heuristic applied to VM placement
(Ferdaus, Murshed et al. 2014)	CPU, memory, network i/o	Migration and recnfigaration overhead	Improved overall resource utilization	Vector algebra based capturing of resource utilization
(Tao, Li et al. 2015)	CPU, memory, storage	Bucket code is asymmetric	Energy consumption is reduced	Bucket coding and learning

Table 3: Genetic Algorithm survey

4) *Method 4:* Flower Pollination Algorithm

Author and year	Parameter used	Limitations	Advantages	conclusion
(Abdel-Basset and Shawky 2019)	Tail amplitude, scaling factor, Switching probability	Standard FPA algorithm not defined	Can be applied to many areas like Neural Networks, Medicine	Tension/compression spring design problem is analyzed
(Usman, Ismail et al. 2019)	Random walk L, Switching probability, Maximum iteration, Population size	Finds the near optimal solution but not highly scalable	Finds a better solution in terms of energy consumption and resource utilization	proposes Energy-oriented Flower Pollination Algorithm (E-FPA) for VM allocation
(Khurana and Singh 2019)	Number of tasks, Number of workflows, Number of VM, MIPS, RAM, BW, Number of Processors, VM Policy	Higher computational cost	Time complexity reduced	Proposes hybrid optimization approach (FPA and GWO algorithm)
(Gamal, Rizk et al. 2019)	Pheromone, load balance, CPU utilization, memory, bandwidth, and the storage size, respectively	More SLA Time per Active Host (**SLATAH**),	Finds the optimal PM based on least power consumption	VM placement by OH_BAC algorithm
(Joda, Ismail et al. 2018)	Power Usage Effectiveness, Clustering	Multi-Objective approach of FPA not considered	overcome the limitation of using single Cloud datacenter	proposes Energy-Aware distributed Multi-Cloud Flower Pollination Optimization (EAdM-FPO)

Table 4: Flower Pollination Algorithm survey

5) *Method 5:* Fruit Fly Optimisation Algorithm

Author and year	Parameter used	Limitations	Advantages	conclusion
(Naik, Singh et al. 2018)	Migration Time, Communication Cost, Load Balance	SLA violation and communication overhead is not considered	reduce the host migration and consolidates VMs under-utilized hosts	Proposes multi-objective Fruitfly hybridized Cuckoo Search algorithm
(Mitić, Vuković et al. 2015)	Alpha (source of food), chaotic variable, success rate		Higher convergence speed and overall performance	Investigates different FFOA
(Meng and Pan 2017)	harmony memory size (HMS), harmony memory considering rate (HMCR), pitch adjusting rate (PAR), distance bandwidth (bw) and the number of improvisations (NI)	Not very efficient when used for very large sets of data	Uses FFOA to solve the MKP (multidimensional knapsack problem)	self-adaptive repair mechanism (SACRO) described
(Wu, Zuo et al. 2015)	Entropy, maximum iteration number, population size, random flight distance range	multi-objective optimization not covered	CMFOA has better global convergence ability compared with other FFOA schemes	Uses parameter entropy to improve the global search ability
(Wang, Liu et al. 2016)	level probability policy, mutation parameter, Maxtime, popsize	more complex than other variants of FOA,	more effective and robust than the IFOA1, IFOA2, DE, and PSO	Proposes LP–FOA

Table 5: Fruit fly Optimisation Algorithm survey

6) *Method 6:* honey bee algorithm:

Author and year	Parameter used	Limitations	Advantages	conclusion
(Upadhyay, Bhattacharya et al. 2018)	Overhead, Scalability, Throughput, Response Time		Discuss various algorithms to handle higher throughput, efficient resource utilization, low response time	proposes a K-mean clustering method
(Sudhakar, Jain et al. 2018)	Load on the server, Priority of the task, Size of the file	Storage space not considered	Higher performance with respect to response time and processing time	Large file is divided into multiple pieces and each pieces is treated as separate run on different servers
(Zanbouri and Navimipour 2019)	QWS(quality-of-web-service), cluster, trust degree, tag value, service	not efficient in large-scale data sets	efficient in term of computation time for small data sets	Proposes honeybee mating optimization algorithm and trust-based clustering
(Verma and Bhatt 2019)	Memory, BW, Region, Request Per Hour, Data Size	data processing and response time are not fully optimized		Various nature inspired algorithms are discussed
(Verma, Sharma et al. 2018)	Broker cost, Time duration, Bandwidth, Ram speed, Overall cost	Server CPU power, memory not considered	achieve well balanced load across virtual machines for maximizing the throughput	Proposes Honey bee behaviour inspired dynamic load balancing (HBB-LB)

Table 6: Honey Bee Algorithm survey

IV. CONCLUSION

In conclusion, this papers serveys different nature inspired algorithms and its application for optimal selection and placement of virtual machines in a cloud based environment. The various parameter considered include memory, bandwidth, RAM speed, computation time and cost etc. Each algorithm has its own limitations and to find a very optimal solution will require developing a new solution based on the specific application requirements.

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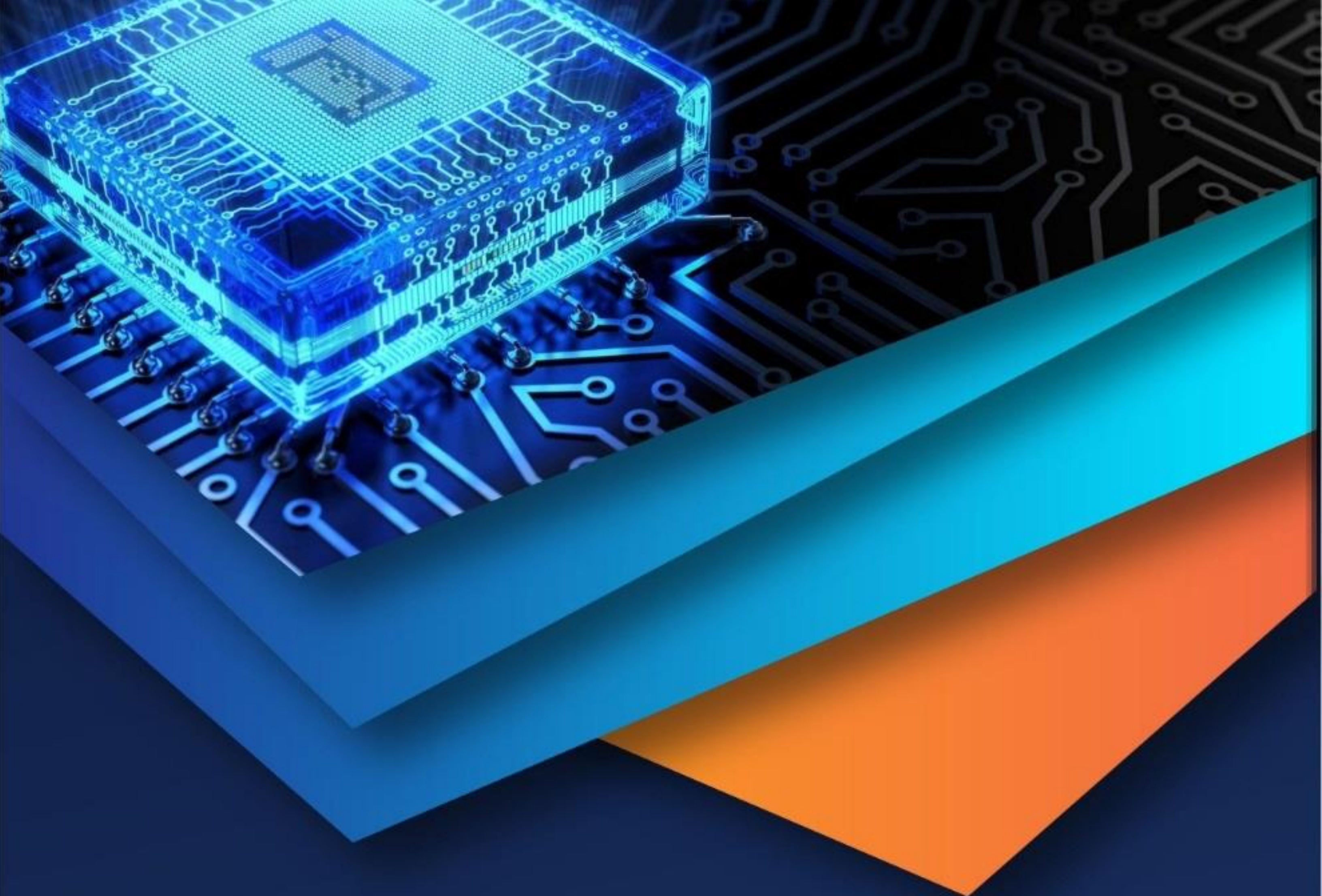

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