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An Efficient Virtual Machine Placement Approach for Energy Minimizing in Cloud Environment

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Abstract:
Cloud computing can be defined as an evolving Computing technology using the Internet and essential remote infrastructure to retain on-demand and pay-as-you-go assets. The number of data centers across the world has increased through wide adaptation to cloud principles, leading to large amounts of data center power consumption that affects the climate and economic aspects. So many virtual machines (VMs) could be installed on one Physical Machine(PM) via virtualization. The Cloud workload is held by these VMs and executed. Effective PM allocation of VMs will lead to better use of resources and energy savings. In this paper, our goal is to provide an improved Policy on energy-efficient VM placement to minimize energy consumption in the cloud environment, placing the VMs in the addressed bin backing mechanism and retaining the Service Level Agreement (SLA) between the provider and the cloud customer. Significant reduction in power consumption could even be made if convective are implemented at software level. Energy -aware scheduling processes produces excellent performance by implementing bin-packing energy efficiency mechanisms. An improved algorithm has been enhanced for the two First Fit Decreasing FFB and Best Fit Decreasing BFD algorithms, which are considered the best among bin packing algorithms. This algorithm adopts server power as the basis for arranging servers in the database, unlike the BFD, FFD algorithms that arrange servers according to CPU. The proposed algorithm has been practically tried using Matlab 2020 programing language for samples of servers and virtual machines, whose specifications were chosen randomly, and the results showed great efficiency of the proposed algorithm in reducing energy consumption.

Key Words: Cloud Computing, VM Placement, Energy Consumption, Bin Packing

1. Introduction:

Internet-based cloud computing offers pooled computing services and on-demand access to data[1]. Cloud computing offers servers, software and services that are accessible to consumers on a supplier-user acceptance basis. Users use pay-per-use cloud services. There are three kinds of services in cloud computing, such as Infrastructure as a Service (IaaS), Application as a Service (PaaS) and Software as a Service (SaaS). The deployment model of the Cloud has numerous advantages, such as QoS, reliability, ease of use, robustness, etc.[2]. Internet-based cloud computing offers pooled computing services and on-demand access to data[1]. The foundation of working in the cloud world is Previa Cloud Infrastructure

Technology for virtualization [3]. In virtualization, user resources are demanded in terms of virtual machines and then provisioned on different hosts based on storage, memory, bandwidth, etc, requirements [4]. Virtualization can help to maximize the use of resources and reduce the consumption of electricity. Multiple VMs can be deployed on one physical machine by virtualization [5]. Virtualization utilizes file abstraction to provide mapping across virtual resources and physical resources. Applied virtualization and file storage abstraction [6]. Based on specific parameters, VMs are put on various hosts, such as the Service Level Agreement (SLA) between cloud provider and costumers [7]. The placement objective can either maximize the use of available resources or save energy by the ability to suspend those hosts [8]. It is NP's difficult problem to assign virtual machines to physical machines and this issue can be treated by first-fit or best-fit method [9]. In this study, proposed VM allocation algorithm for reducing power consumption using bin backing mechanism has been used. As follows, the remainder of the paper is structured. Section 2 addresses similar studies carried out in the sector in recent years. Section3 explain problem statement, Section 4 illustrate power model, section 5 addresses our proposal. Concluding the proposed work in section 6 and list the references afterwards.

2.Related Work:

The problem of consolidation is well formulated in the works of Guazzone et al. (2012) as an optimization function [10]. The objective function is a linear combination of cost of energy, VM migration and cost of performance degradation. The resulting mathematical programming is a Mixed-Integer Nonlinear Program (MINLP) which is known to be NP-hard. The only known solution to an NP-hard problem is an exhaustive search which is infeasible for dynamic cloud environment owing to its slow convergence. Some research works give a different formulation of the consolidation problem. For example, Rawas et al. (2018) formulate the consolidation problem in context of Geo-distributed data-centers [11]. Accordingly, their equation considers power-effectiveness of data-centers and users to data-center communication costs in additional to cost of energy in each data-center. In all cases, the optimum solution (exhaustive search) is infeasible owning to its slow convergence.

Several approximate consolidation solutions are proposed in the literature [12, 13, 14]. In these approximate solutions, the VM placement decision is handled with simple heuristics such as a modified form of best-fit and first-fit decreasing In the works of Beloglazov et al. (2014), the VM placement problem is handled by the MBFD algorithm [12]. The algorithm deals with minimizing the number of active servers and is based on a bin-packing heuristic called Best-Fit Decreasing (BFD). The default VM placement algorithm in CloudSim cloud simulator is the Power Aware Best-Fit Decreasing (PABFD). The PABFD places the current VM on a host that fits it and the estimated increase in power is the minimum. Chowdhury et al. (2015) proposed Power-Aware Worst-Fit Decreasing (PAWFD) algorithm which favors a host whose estimated increase in power utilization is the maximum (quite the opposite of PABFD) [14]. Their experiment shows that PAWFD has better performance than their baseline algorithm, PABFD.

A comprehensive performance analysis of various VM placement algorithms is conducted by Z. Mann and M. Szabo (2017) [15]. For overload and underload detection, the authors reuse algorithms from OpenStack Neat framework. The VM placement algorithms considered for comparison include PABFD and PAWFD. The best performing algorithms are the “Guazzone” [10] and the “Shi-AC” [16] algorithms. The “Guazzone” algorithm is from the works of Guazzone et al. (2012) [10] and it applies three host selection criteria: (1) powered-on host proceeds powered-off host, (2) within powered-on or powered-off host category, hosts are selected by decreasing size of free CPU, and (3) in case of same CPU capacity, hosts are selected by increasing values of idle power consumption. The “Shi-AC” is from Shi et al. (2013) and assigns a VM placement by favoring a server with the largest absolute CPU capacity [17].

To address the issue of unnecessary VM migrations and an increase in SLA violation caused by heuristics that only deal with minimizing the number of servers RawasS, ZekriA, ZaartAE (2018), WangS, ZhouA, HsuCH, XiaoX, YangF (2016). prediction aware VM placement [18,19]. The proposed algorithm called Utilization Prediction Aware Best-Fit Decreasing algorithm (UP-BFD) chooses a host based on the prediction of future resource utilization. Their simulation result shows that UP-BFD performs better than those that are not utilization prediction aware. The authors provide a whole set of prediction aware algorithms for consolidation.

The VM placement algorithms we propose like most of the above works are based on bin-packing. The complexity of bin-packing based VM placement algorithms are very simple. It is proportional to the number of VMs to the number of hosts. This is much simpler than evolutionary computation techniques that also involve the number of populations and iterations.

3. Problem Statement:

An efficient VM placement algorithm is expected to allocate computing resources in such a way that it satisfies VMs’ resource demand and minimizes energy utilization with the least number of VM migrations possible. Many of the VM placement algorithms are based on bin-packing algorithms. The problem of VM placement is analogous to problem of bin-packing where items of different sizes are assigned to bins of different size. In this paper, we presented an improved algorithm resulting from the improvement of the First Fit Decreasing and Best Fit Decreasing algorithms to help reduce the energy consumed by the servers in the database.

4. Energy Model

Energy consumption for Physical Machines (PMs) in data centers is generally specified by CPUs, cooling systems, energy supplies, memory and disk storage. Even when dynamic voltage and frequency scaling are used, the energy consumption of PMs could be described using linear CPU utilization relationships. Due to the fact that a CPU and the other device elements, such as network interfaces and memory, have a small number of frequency and voltage states, voltage and frequency scaling are not used. The work in [7, 18] shows that a PM uses about 70 percent of its full energy consumption when it is idle. As stated in [7, 19], it is possible to define the energy consumption of PM as

$(u) = 0.7 \times Pmax + 0.3 \times Pmax \times u$

Such that is the maximum energy of fully utilized PM. u is CPU utilization.

Along with their calculation equation, the associated significant terminologies are:

Server Utilization: As virtual machine instances are loaded on it, it is the complete use of a server, it is denoted by the symbol Ui (R, t). The value gained as a server utilization metric should not be more than one It is estimated by the equation [19]

$$U_i(R,t)=\sum_{k=1}^{v} R_{I,}*\left(\frac{computing\ requirement\ of\ virtualmachine\ k\ on\ server\ i}{computing\ capacity\ of\ server\ i}\right)\ldots.(1)$$

The hosting of the k virtual machine on the I cloud is denoted by Rk_i and has a value of 0 or 1. Meaning is 1 when the VM is located on the host , else it take the value 0.

Power Consumption:

It is the energy utilization of a host once the VMs instances are located on. It is represented by P_i (R, t). An idle server utilizes about 70% of the total energy respectively when it is properly utilized. It is estimated by the equation [7]

$$P_i (R, t) = 0.7Pmax + 0.3Pmax * U_i (R, t) \quad \text{……………. (2)}$$

Total Computing Requirement:

It refers to the overall computational needs of all instances of a given server's virtual machine and is defined by T _CPU_i. It is estimated by the equation [19]

$$T\_CPU = \sum_{K=1}^{N} Rec\_CPU_k \quad \text{……………..(3)}$$

Total power Consumption: It is considered the total power utilization of all data center servers and is described by TPC. It is calculated by the equation [19]

$$TPC = \sum_{i=1}^{M} P_i(R,t) \quad \text{………………..(4)}$$

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5. Proposed Work:

Bin-packing system is the natural solution for the issue of VM allocation. In bin-packing, objects are allocated to buckets (bins) to minimize the number of bins with the optimization target. Sizes of values not exceeding the size for bins are defined by the products. It is well known that the bin-packing issue is NP-hard and, thus, it is impossible to find an exact solution or to be ineffective (for very dynamic problems). Given a variety of virtual machines and physical servers, it is important to achieve a suitable placement of available VMs on the physical machines that minimizes the total energy consumed by active physical machines. To solve this problem, and based on the FFD and BFD algorithms, which are considered among the best algorithms for bin backing, an algorithm has been proposed.

PRBFD (Power-Redaction-Best-Fit –Decreasing): algorithm for bin-packing which main objectives are to minimize the total energy expended in the virtualized cloud world. The algorithm operates in the same way as BFD, but the opening of the servers has been distinguished. Initially, all the servers are considered unused and unassigned by the algorithm. Then VM's are allocated to them on the basis of the power usage of servers. The assignment begins with the server that has the lowest overall power consumption value. The list of VMs is preserved in the ascending order of their computational power. The minimum VM-demanding capacity is first considered and is put among the other servers on a server with its Pmax as the least value. Furthermore, when two or more hosts have the same Pmax rating, then the allocation is carried out according to host computing capabilities. For packaging, the host with the highest processing capacity will be chosen first. That process will continue till the servers are assigned to the entire VMs or the computational capacity of VMs considered and placed on a host exceeds the computing capacity of the server. If the placement has been completed, total energy expended in cloud setting is measured in the same of the BFD process.

Algorithm 1: PRBFD:

Input: host list, VM list

Output:VM placement

1. 1. Initialize criteria for capacity to Req_CPU_i, CPU_i, memory resource and $power_{max}$ for every host H_i and VM

2. Sort VM's in Ascending order according their capacity of computing
3. Sort the hosts in Ascending order of their maximum energy requirements
4. Hosts that have the same $Power_{max}$ value will be sorted in decreasing order of their capacities of computing
5. Repeat step 6 till every VM's have been assigned
6. For every host Hi, allocate the VM to Hi from the top of the list in such a way that: $T\_CPU\_VM_i$ <=CPU $\_H_i$ && H_i have enough memory resources
7. Turn off all hosts that do not have a VM and uninstall the host list entry.
8. Compute power spent of each host Hi as P_i (F, t)
9. Compute the total power consumption and total utilization

Algorithm 2: BFD

Input: host List, VM List

Output: VM Placement

1. Initialize requirements of capacity for Req_CPU_i, CPU_i and Power $_{max}$ for every hos Hi i and VM
2. Sort the VM's in descending order of their capacities of computing in vm list
3. Sort hosts according to their capacities of computing in ascending order in host list
4. Repeat step 5 till every VM's have been assigned
5. For every host Hi, locate the VM from the top of the list to Hi SO that: $T\text{-}CPU_i$ <= CPU_i&& H_i have enough memory resources
6. Turn off all hosts that do not have any VM and remove the entry from host list
7. Compute power spent for each host Hi
8. find the total power consumption of the system

Algorithm3:(FFD):

Input: host List, VM List

Output: VM Placement

1. Initialize requirements of capacity for $RequerCPU_i$, CPUi and $Power_{max}$ for every host Hi and VM
2. Sort VM's in descending order for their capacities of computing in VM list
3. Repeat step 4 til all VM's have been assigned
4. For every server H_i, allocate the VM from top of the list to H_i in which: T_CPU_i<=CPU_i && H_i have enough memory resources
5. Turn off all of the hosts that dont have any VM and remove the entry from host list
6. Compute power spent of each server H_i
7. Find the total power consumption of the system

The algorithm was practically implemented in Matlab 2020 programing language, and a number of servers and virtual machines were randomly selected. The results obtained from comparing our algorithm with the basic algorithms (3) and (2) showed the superiority of the proposed algorithm by reducing the number of efficient servers and thus reducing the system power consumption. For example, we have the following inputs:

Table1 Input host**:**

Host number	cpu	power	memory
1	14	4	30
2	10	6	40
3	13	8	45
4	11	23	53

Table2 Input VM:

Vm number	cpu	memory
1	5	10
2	4	5
3	3	3
4	3	7
5	2	4
6	1	8
7	3	2
8	5	3
9	7	2

When representing the inputs in each of the above algorithms, we get the following results

BFD:

Table3 CPU Utilization and energy in BFD:

U1 (%)	U2 (%)	U3 (%)	U4 (%)
0.5	0.9	0.769	0.636

Energy is:

E1(KW)	E1(KW)	E3(KW)	E4(KW)
3.4	5.82	7.446	20.491

TOTAL Eergy=37.157 KW
TOTAL Utilization = 2.807 (%)

FFD:

Table 4 CPU Utilization and energy in FFD:

U1 (%)	U2 (%)	U3 (%)	U4 (%)
0	1	0.923	1

Energy is:

P1(KW)	P2(KW)	P3(KW)	P4(KW)
0	6	7.815	23

TOTAL Energy=36.815 KW
TOTAL Utilization =2.923 (%)

PRBFD:

Table 5
CPU Utilization and Energy in PRBFD:

U1 (%)	U2 (%)	U3 (%)	U4 (%)
0.85714	0.9	0.923	0

Energy is:

P1 (KW)	P1(KW)	P3(KW)	P4(KW)
3.828	5.82	7.815	0

TOTAL Utlization= 2.680 (%)
TOTAL Energy = 17.464 KW

In order to prove the efficiency of the proposed algorithm, we used random numbers of servers and virtual machines. When the virtual machines were distributed on servers according to the above algorithms, the results were as shown in the following table:

Table 6: Average of algorithms performance in the heterogeneous-scenario

No. of Server simulated	**No. of Vms**	**Resource Utilization %**			**Energy Spent(KW)**		
		BFD	**FFD**	**PRBFD**	**BFD**	**FFD**	**PRBFD**
٤	**٩**	**2.472**	**2.714**	**2.335**	**18.735**	**16.742**	**12.064**
٧	**١١**	**4.501**	**4.369**	**3.168**	**61.415**	**66.064**	**60.307**
٥	**١٤**	**4.365**	**5**	**3.689**	**50.391**	**53**	**47.891**
6	**13**	**4.352**	**4.836**	**3.946**	**167.196**	**172.893**	**142.231**
6	**10**	**3.785**	**4.413**	**2.796**	**64.954**	**68.676**	**43.495**
5	**10**	**3.297**	**3.657**	**2.791**	**151.803**	**155.261**	**124.722**

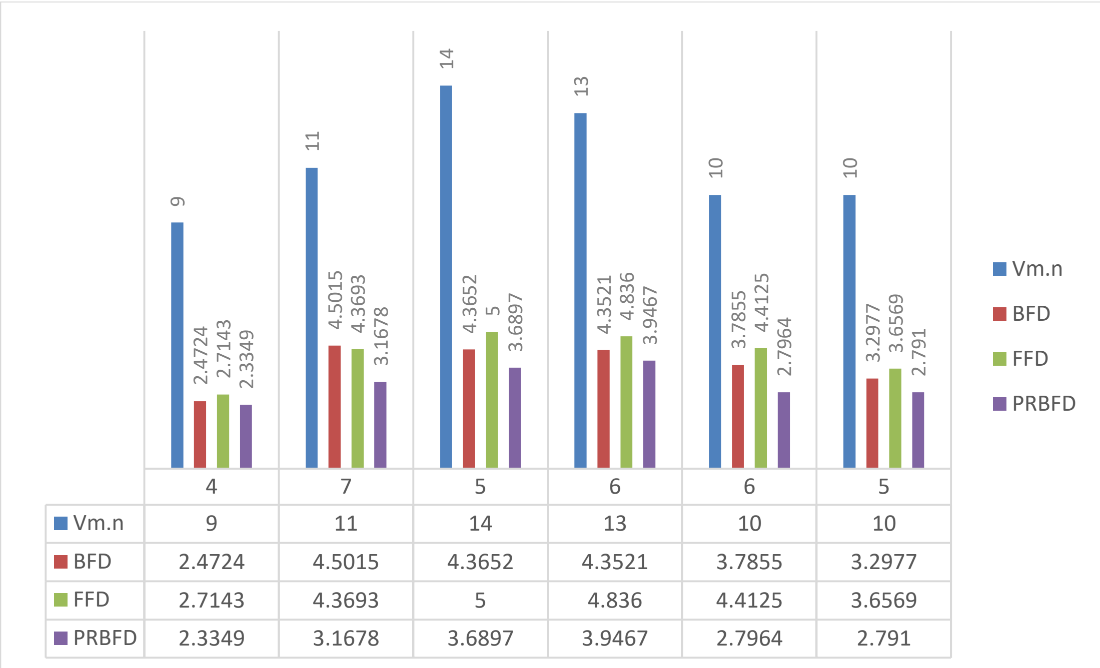

Figure 1: Comparison in Terms of Utilization

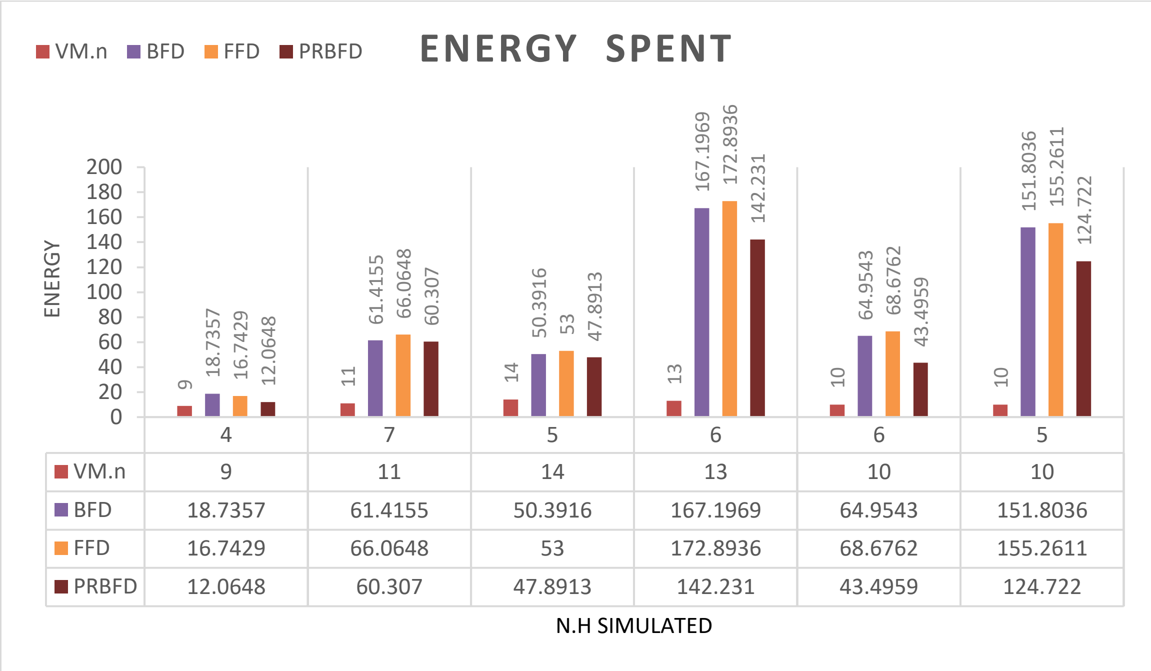

Figure 2: Comparison in Terms of Energy Spent

The percentage of CPU usage for the proposed algorithm compared to the basic algorithms was as in table

Table 7: The percentage CPU Utilization

PRBFD	FFD	BFD
2.335	2.714	2.472
3.168	4.369	4.501
3.689	5	4.365
3.946	4.836	4.352
2.796	4.413	3.785
2.791	3.657	3.297
28.16%	37.59%	34.25%

we can note the percentage of energy consumption by the system in table ٨

Table 8 :The percentage of Energy Spent

PRBFD	FFD	BFD
12.064	16.742	18.735
60.307	66.064	61.415
47.891	53	50.391
142.231	172.893	167.196
43.495	68.676	64.954
124.722	155.261	151.803
29.14%	36.04%	34.81%

6. Conclusion

In cloud environments, VM placement is a critical problem. The problem of finding an effective algorithm capable of reducing power consumption has become more important due to the enormous power consumption in cloud data centers. In this paper, an algorithm based on the bin backing mechanism for reducing power consumption. The generated results validate the proposed architecture and prove its efficiency in reducing the energy consumed in the system. We have proposed VM placement algorithms by modifying bin-packing heuristics considering the power-efficiency of hosts .We arranged the VM in ascending order according to CPU utilization, so that the servers that spend less energy fill the market first. This process will reduce the number of active servers, thus reducing the amount of energy spent by the system. The proposed algorithms improve energy efficiency when compared with the baseline algorithms: BFD and FFD. The improvement in energy efficiency over BFD can be up-to 5%, depending on the data-center host types and workloads and up-to 7% over FFD So is the case in CPU utilization, the proposed algorithm reduces it up -to 6% over BFD and up-to 9% over FFD

References:

1. P. Mell and T. Grance, "The NIST Definition of Cloud Computing," National Institute of Standard and Technology, Information Technology Laboratory 800-145, 2011.
2. R. Buyya, S. Pandey, and C. Vecchiola, "Cloudbus toolkit for market oriented Cloud computing", International Conference on Cloud Computing, pp. 24–44, 2019.
3. H. Hu, X. Zhang, X. Yan, L. Wang, and Y. Xu, Solving a New 3D Bin Packing Problem with Deep Reinforcement Learning Method, arXiv:1708.05930, 2017.
4. A. Andrae, Total Consumer Power Consumption Forecast, 2017.
5. Kaur, Taran deep, and Inderveer Chana. "Energy aware scheduling of dead line constrained tasks in cloud computing." Cluster Computing 19.2, 679-698, 2016.

6. F. Hermenier, X. Lorca, J.-M. Menaud, G. Muller, and J. Lawall, "Entropy: a consolidation manager for clusters," in Proceedings of the 2009 ACM SIGPLAN/SIGOPS international conference on Virtual execution environments, VEE '09, (New York, NY, USA), pp. 41–50, ACM, 2009.
7. Smith, James; Nair, Ravi. "The Architecture of Virtual Machines". Computer. IEEE Computer Society,2005.
8. Xiong FU and Chen ZHOU," Virtual machine selection and placement for dynamic consolidation in Cloud computing environment" ,2015.
9. R. Ranjana, S. Radha, J. Raja," Performance study of resource aware energy efficient VM Placement Algorithm" 2016.
10. A. Beloglazov and R. Buyya, "Optimal online deterministic algorithms and adaptive heuristics for energy and performance efficient dynamic consolidation of virtual machines in Cloud data centres," Concurrency and Computation: Practice and Experience, vol. 24, no. 13, pp. 1397–1420, 2012.
11. BeloglazovA,BuyyaR.Openstackneat:Aframeworkfordynamicandenergyefficientconsolidationofvirtualmachinesinopenstack clouds. Concurr Comput Pract Experience ,2014.
12. Chowdhury MR, Mahmud MR, Rahman RM: Implementation and performance analysis of various VM placement strategies in CloudSim. J Cloud Comput 4(1):1–21, 2015.
13. Mann ZÁ, Szabó M: Which is the best algorithm for virtual machine placement optimization? Concurr Comput Pract Exp 29(10):4083, 2017.
14. Farahnakian F, Pahikkala T, Liljeberg P, Plosila J, Tenhunen H: Utilization Prediction Aware VM Consolidation Approach for Green Cloud Computing. Proc - 2015 IEEE 8th Int Conf Cloud Comput Cloud :381–388, 2015.
15. MannZÁ, SzabóM." Which is the best algorithm for virtual machine placement optimization?" ConcurrComput PractExp29(10):4083,2017.
16. Leena, V. A., Ajeena Beegom AS, and M. S. Rajasree. "Genetic algorithm based bi objective task scheduling in hybrid cloud platform." International Journal of Computer Theory and Engineering 8.1, 7-13, 2016.
17. Singh, Sukhpal. Efficient cloud workload management framework. Master thesis in Software Engineering, Thapar university patala, 2013.
18. RawasS, ZekriA, Zaart AE "Power and cost-aware virtual machine placement Ingo-distributed datacenters". In: Proceedings of the 8th InternationalConferenceonCloudComputingandServicesScienceVolume1: Closer.SciTePress. pp112–123,2018.
19. Beloglazov, A., Buyya, R.: Adaptive threshold-based approach for energy-efficient consolidation of virtual machines in cloud data centers. In Proceedings of the 8th International Workshop on Middleware for Grids, Clouds and e-Science, 2010