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Investigating Solutions to Reduce Energy Consumption in Cloud Data Centers

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Abstract - In infrastructure layer, cloud computing technology provides the possibility of using computing and storage resources as a service according to the type of requirements. Moreover, it makes dynamic resource management feasible through generating an abstract layer on whole physical resources by virtualization. The goal of current research is to present intelligent water drop algorithm to achieve a method for optimal installation of virtual machines on physical machines embedded in data center in order to reduce power consumption and consequently reducing the number of active physical servers as well as decreasing waste amount of resources. In fact, presenting this algorithm results in reducing costs of maintenance and infrastructure's service providers since the biggest part of maintenance cost is related to energy consumption. Therefore, the most benefit will be achieved by service provider once it can make energy consumption the least. CloudSim simulator has been used to simulate all IWD, GA, PSO, and MBFD algorithms with the purpose of resource management in cloud computing. Outcome results show that among current methods of intelligent water drop algorithm, using MAD algorithm as overload detection algorithm and MMT algorithm as virtual machine selection algorithm can provide the most optimal answer for physical resources' management in cloud computing.

Keywords - *Cloud Computing, Resource Management, Water Drop Algorithm, Intelligent Water Drop.*

1. Introduction

With the increasing advance of information technology and various applications, coherent computing is undoubtedly necessary for majority of the users. Regarding to users' different application requirements, various processing processes would be required. In case of performing these processes in a quite more advanced way, they would be in need of many and various processing but hence this would not be possible for a large number of users, so using technologies such as Cloud Computing which does users' computing processes through accepting their requirements and feedback achieved results seems to be highly necessary. Using Cloud Computing is coming to become a hot discussion in industry and academy as the new mechanism of computing. Computing has been provided as a tool to response daily needs of the society. Cloud Computing is a computer model trying to accelerate users' access to the information and computing resources based on the type of their demands. This model tries to response users with the least need of human resources and reducing costs while speeding up access to information [1].

Any place in the world, Cloud computing has provided a proper infrastructure for trading and using services and application based on demand. Thus, it has been highly considered as a new pattern to provide dynamic computing services. Moreover, huge processing can be easily done using cloud computing. The ides of cloud computing would be the same with evolved parallel processing, distributed processing, and network processing. Also all provided services in cloud computing are web-based which means a software system is to be designed to support interactions among machines all over the network [2]

The cost of service providers of infrastructure as a service would be more associated with their maintenance rather than using infrastructure while the most maintenance cost is related to energy consumption; so the most benefit will be achieved by service providers once they can make the least of energy consumption. It should be considered that

resource allocation method has a direct relationship with this energy consumption and service providers' benefit. A typical data center normally consumes power equal to the consumption of 2500 household subscriber and energy costs in data centers typically doubles every five years. So it can be seen that not only maintenance cost of data centers are too high but also they are also very harmful for the environment [3].

Possessing the most effective approaches and selections among all criteria, methods, and principles for decision making in order to achieve the goals, Heuristic algorithms can play a considerable role in cloud computing. Heuristics are the result of a balance between two needs. Social complex systems are involved in numerous problems with a compound nature which we have to face.

Metaheuristic algorithms are one of these ones containing algorithms which are explicitly or implicitly managing the contrast between search diversification (when there are signs that exploring is going to bad regions of search space) and search intensification (with the aim of finding the best answer within the studied region). In current research, intelligent water drop algorithms has been used which is a metaheuristic algorithm to optimize based on collective intelligence. Water drop algorithm is working in group and should also be considered to be naturalistic.

Intrinsically, the IWD algorithm can be used for combinatorial optimization. However, it may be adapted for continuous optimization too. Experiences have shown that answer in solving complex problems, this algorithm as a combination of coordination and competition among intelligent water drops could achieve a more proper than the other methods. Therefore, the main questions of this research is that regarding to the results, does IWD algorithm provide a more optimal method comparing to the proposed algorithms for physical resource management and reducing energy consumption. And on the other hand, if the answer is positive, then which one of physical and virtual machine selection methods will result in better answer with this algorithm. Continuing the research, former researches, methodology, and implementation will be discussed and results will be presented through comparing proposed algorithm with the other methods.

In the following sections, history of research will be studied in section 2. Then in section 3, simulation \scenarios will be explained and results of the simulation will be analyzed and comprised in section 4. Finally the results will be stated in conclusion section.

2. History of Research

Yongqiang & Haibing [4] have used ant colony algorithm to solve the problem of resource allocation to virtual servers in order to reduce energy consumption as well as decreasing resource waste. However, in this research, a modified form of the ant colony algorithm is used that is suitable for multi-objective problems.

Wang et al, [5] has solved the problem of optimal locating of virtual machines on physical servers through using discrete Particle Swarm Algorithm in order to reduce power consumption.

Vignesh et al, [6] have proposed a model for planning work-oriented resources in cloud computing environment, and allocation responsibility for resource process; which available resources and users' preferences are implemented.

Palanilllumar et al, [7] have surveyed "service selection and combination in service-oriented architecture based on intelligent water drop algorithm" in a paper. Using intelligent water drop or IWD algorithm in this paper, they have embedded ideas in website based on the selection done by web service and combining that to provide qualified and efficient service. Proposed algorithm provides a better performance for computing and optimization particle swarm optimization (PSO) algorithm.

Basem et al, [8] have studied "A modified Intelligent Water Drops algorithm and its application to optimization problems". In their paper, the effectiveness of the selection method in the solution construction phase of the IWD algorithm has been investigated. Also Instead of the fitness proportionate selection method in the original IWD algorithm, two ranking-based selection methods, namely linear ranking and exponential ranking, have been proposed. Both ranking-based selection methods aim to solve the identified limitations of the fitness proportionate selection method as well as to enable the IWD algorithm to escape from local optima and ensure its search diversity. To evaluate the usefulness of the proposed ranking-based selection methods, a series of experiments pertaining to three combinatorial optimization problems, i.e., rough set feature subset selection, multiple knapsack and travelling salesman problems, is conducted. The results demonstrate that the exponential ranking selection method is able to preserve the search diversity, therefore improving the performance of the IWD algorithm.

3. Simulation Scenarios

In this research, CloudSim simulator has been used to simulate all IWD, GA, PSO, and MBFD algorithms in order to manage the resources in cloud computing. Also [9] has been used to get a thorough evaluation of mentioned algorithms' simulation of presented scenario. Each one of mentioned algorithms have been separately simulated based on virtual and physical machines selection method so that ultimately as well as selecting the best algorithm, the most suitable method can be introduced for overhead detection in virtual machine and physical server. Because of the accidental nature of input values of the proposed model, every algorithm is run for 40 time and after recording the best answer, this process will be repeated for 10 times in order to generating variable conditions of the real environment including different changes in data centers and the outcome is recorded for each repetition and afterwards, the average of this process achieved after 400 times running of the algorithms will be compared with the other algorithms.

A typical data center has been simulated by 100 heterogeneous physical node. There are a CPU core with the performance of 1000, 2000, or 3000 million orders in a second (MIPS), 8 gig ram and 1 terabyte storage space in each node. Energy consumption of a physical host is within the range of 175 W with 0% CPU usage to 250 W with 100% CPU usage. Every virtual machine requires a CPU core with 250, 500, 750, or 1000 MIPS, 128 Mb ram, and one GB storage space. User sends their request to supply 290 homogeneous virtual machines which simulate and record the whole capacity of data center. Each virtual machine runs an under-web application or any other kind of application with variable workload modeled for generating CPU usefulness according to a single distributed random variable. The application is for 150,000 MIPS which is equal to 10 min running on 250 unit CPU at 100% productivity. First, VMs are considered according to requested features and assumption of 100% usage. Then all experiments will be run for 10 times. Current results have been made on the basis of average values [9].

4. Results of the Simulation

In this section, some conditions have been considered for investigating energy consumption in four algorithms of IWD, GA, PSO, and MBFD; so that overhead detection in physical host would be based on MAD algorithm and immigrant VM selection would be based on MMT algorithm. As demonstrated in table and Fig 1, algorithms' energy consumption has been illustrated using MAD algorithm for overhead detection and MMT algorithm for VM selection; the average of 10 optimal answers of IWD algorithm is associated with less energy than the three other methods.

Considering the results of done surveys, it is obvious that in the optimal answer of ten-step implementation in 5 cases with low processing load on physical host, compared algorithms consume intangibly less energy comparing to IWD. In another word, utilizing IWD algorithm in this method for high-traffic data centers with excessive load on physical host presents a better answer.

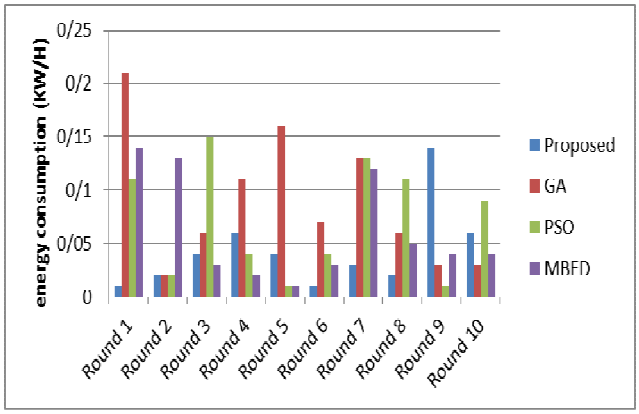

Fig. 1 Energy consumption of the algorithms using MAD and MMT algorithms

The other problem is what has been pointed before about MMT algorithm which that this method would not be proper if a large memory free-up is needed to go out of the state of overload while in contrast, if a little memory free-up would be free, this method performs very well. Anyway, what is ultimately considered is the average energy consumption of different working conditions that in this case, the Median Absolute Deviation algorithm is utilized for overhead detection in physical host and minimizing migration method is used for VM selection, and the average value for 400 times repetition for IWD algorithm is equal to 43 W/H which can be considered as an appropriate amount comparing to the other discussed methods.

Overhead detection in physical host is done based on IQR algorithm and immigrant VM selection is done based on MMT algorithm so that on this basis, energy consumption of IWD, GA, PSO, and MBFD algorithms would be compared. Surveying simulation results, it can be observed that in the separate ten-step optimal answer in four cases which in the processing load of physical host is low, again using compared algorithms consume intangibly less energy.

Table 1: Energy consumption of the algorithms using MAD and MMT algorithms

	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Round 9	Round 10	AVG (KW/H)	AVG (W/H)
Proposed	0.01	0.02	0.04	0.06	0.04	0.01	0.03	0.02	0.14	0.06	0.043	43
GA	0.21	0.02	0.06	0.11	0.16	0.07	0.13	0.06	0.03	0.03	0.088	88
PSO	0.11	0.02	0.15	0.04	0.01	0.04	0.13	0.11	0.01	0.09	0.071	71
MBFD	0.14	0.13	0.03	0.02	0.01	0.03	0.12	0.05	0.04	0.04	0.061	61

In another word, in this method also, utilizing IWD algorithm presents a better answer for high-traffic data centers which in there is an excessive load on physical host. In addition, under different conditions of implementation, states should be considered which in, MMT algorithm does not have a good performance because of the need for a large memory free-up. But despite all possible conditions, the average energy consumption in different working conditions for IWD in this case is equal to 53 W/H.

This amount has a higher energy consumption comparing with the results of section 1 to 4. In another word, based on current results, intelligent water drop algorithm consumes less energy while using MAD and MMT than using IQR and MMT.

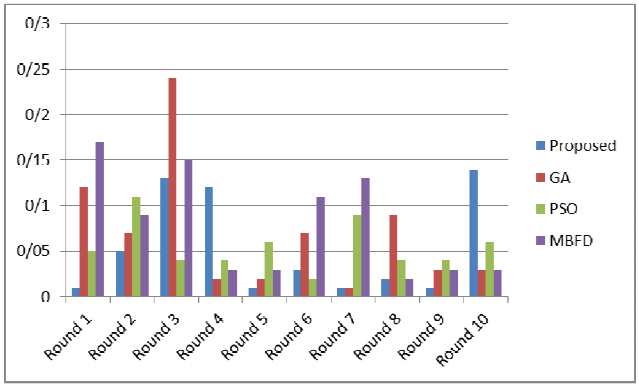

Fig. 2 Energy consumption of the algorithms using MMT and IQR algorithms

Table 2: Energy consumption of the algorithms using MMT and IQR algorithm
s

	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Round 9	Round 10	AVG (KW/H)	AVG (W/H)
Proposed	0.01	0.05	0.13	0.12	0.01	0.03	0.01	0.02	0.01	0.14	0.053	53
GA	0.12	0.07	0.24	0.02	0.02	0.07	0.01	0.09	0.03	0.03	0.07	70
PSO	0.05	0.11	0.04	0.04	0.06	0.02	0.09	0.04	0.04	0.06	0.055	55
MBFD	0.17	0.09	0.15	0.03	0.03	0.11	0.13	0.02	0.03	0.03	0.079	79

5. Conclusion

Considering the large number of users and resources in cloud computing, using evolutionary algorithms for physical resource management seems to be a suitable method. Investigating results of separate simulation of all IWD, GA, PSO, and MBFD algorithms based on different policies of physical and virtual machines' selection of the proposed method, as well as MAD algorithm as overhead detection algorithm and MMT algorithm as virtual machine selection algorithm; shows the least amount of energy consumption of 43 W/H. The proposed model reduces energy consumption 9% more than MBDF algorithm, 21% more than PSO algorithm, and 38% than GA algorithm. As demonstrated in table and Fig 2, energy consumption of algorithms have been surveyed through using IQR and MMT algorithms when IQR algorithms which have a good performance in large search spaces are used for physical host overhead detection and MMT algorithms which is used to minimize migration rate; the average of 10 optimal answers of IWD algorithm shows less energy consumption in comparison to the other three proposed method. However investigating energy consumption based on MMT and IQR algorithms for IWD algorithm is equal to 53 W/H which is a higher than the result of MAD and MMT algorithms.

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