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Energy Efficient Dynamic Resource Allocation Technique in Mobile Cloud Computing

Neha Jayant, Gagandeep

***Abstract*− Energy consumption of massive scale mobile cloud data centers is increasing unacceptably. It is the most challenging field of concern these days. So there is a need to improve the energy efficiency of such data centers using server consolidation which aims at minimizing the number of active physical machines in a data center. As the analysis has shown that by applying suitable optimization policies directed through our energy consumption models, it is possible to save 20% of energy consumption in mobile cloud data center. Energy crisis has led a way to green computing. Green computing offers various schemes in order to manage the power usage of these data centers efficiently. This paper presents Virtual Machine Placement technique used in green cloud which is a meta- heuristic approach. This technique subsequently reduces the energy consumption in the mobile cloud data centers and provides improved server consolidation. Also this paper includes the comprehensive study of the various energy consumption techniques in the mobile cloud data centers and various techniques used for managing high levels of the energy consumption.**

***Index Terms*−** Data center, Energy optimization, Green computing, Mobile cloud computing

I. INTRODUCTION

Recently, the applications targeted at mobile devices have started becoming abundant with applications in various categories such as entertainment, business, social networking etc. However, data centers hosting mobile cloud applications consume huge amounts of energy, contributing to high operational costs and carbon footprints to the environment [5][20]. According the research so far, the massive scale data centers are responsible for causing 2 percent of global carbon emission and 1.3 percent of world’s electricity consumption is by the data centers, which is being estimated to grow 8 percent by the year 2020.

As mobile cloud computing technology has become a fast emerging technology these days, most of the IT sector energy consumption happens in data centers. Rapid growth of the demand for computational power by scientific, business and web-applications has led to the creation of large-scale data centers consuming enormous amounts of electrical power [8]. Research says Information and Communication Technology (ICT) industry constitutes 2% of global total CO2 emissions and 3% of global energy expenditure from the energy and environmental point of view [13]. The main sources of power consumption in a mobile data center are cooling, computing resources, and network elements, where cooling constitutes 40% of the total energy consumption in a data center [4]. So, mobile cloud data centers are the strength of today’s demanding IT infrastructure, there is crucial need to improve its efficiency [1]. For this purpose, various energy optimization techniques have been proposed to manage the energy consumption at the mobile cloud data centers .

II. RELATED WORK

Task Consolidation is an effective method to increase resource utilization and in turn reduces energy consumption. Recent studies identified that server energy consumption scales linearly with resource utilization. However Task consolidation can also lead to the freeing up of resources that can sit idling yet still drawing power. There have been notable efforts, typically by putting computer resources into some form of sleep or power saving mode to reduce idle power draw. Lee and Zomaya presented two energy conscious task consolidation heuristics which aim to maximize resource utilization and explicitly take into account both active and idle energy consumptions [13].

Beloglazov, Abawajy and Buyya conducted a survey in energy efficient computing and propose: architectural principles for energy efficient management of clouds, energy efficient resource allocation policies and scheduling algorithms considering Qos expectations and power usage characteristics of the devices and number of open research challenges addressing which can bring substantial benefits to resource providers and consumers [24].

Hsu et al. presented energy –aware task consolidation (ETC) that minimizes energy consumption. ETC achieves this by restricting CPU use below a specified peak threshold. Energy cost model also considers network latency when a task migrates to another virtual cluster. This technique consolidate tasks among virtual clusters. In addition, the energy cost model considers network latency when a task migrates to another virtual cluster. To evaluate the performance of ETC MaxUtil is used which is a recently developed algorithm that aims to maximizecloud computing resources. The simulation results show that ETC can significantly reduce power consumption in a cloud system, with 17% improvement over MaxUtil [15].

Uchechukwu, Li and Shen presented formulations and solutions for green cloud environments to minimize its environmental impact and energy consumption under new models by considering static and dynamic portions of cloud components [20]. Energy efficiency in data centers is discussed in detail with survey of existing techniques in energy savings, green data centers, and renewable energy resources [16].

Boru et al. described the data replication in cloud computing data centers in which both energy efficiency and bandwidth consumption of the system is considered [7]. The energy consumption of the cloud data centers has been growing drastically in recent years. In particular, CPUs are the most power hungry components in the data center. Duan et al. proposed a dynamic idle interval prediction scheme that can estimate future CPU idle interval lengths and thereby choose the most cost-effective sleep state to minimize power consumption at runtime. The development of computing systems has always been focused on performance improvements driven by the demand of applications from consumer, scientific and business domains but the ever increasing energy consumption of computing systems has started to limit further performance growth due to overwhelming energy consumption and carbon dioxide footprints. Pangotra and Sharma presented a hybrid energy efficient resource allocation technique which combines predictive with reactive allocation techniques and accomplishes substantial improvements various fields [9][11].

Zhan et al. described about a novel adaptive scheme to interactively co-optimize the locality and utility of co-scheduled threads in thread-aware shared last level caches (SLLC) capacity management. In cloud environments, several techniques are being used that aim for energy efficiency. Although these techniques enable a reduction in power consumption, they usually impact application performance. Rossi et al. presented an orchestration of different energy saving techniques in order to improve the tradeoff between energy consumption and application performance [23]. Toosi et al. proposed a framework for reactive load balancing of web application requests among Geo-distributed sustainable data centers based on the availability of renewable energy sources on each site. The experiments demonstrate that our approach can reduce cost and brown energy usage with efficient utilization of green energy and without a priori knowledge of future workload [28].

III. Virtual Machine Placement Technique

A. *Energy optimization*

Current real world applications experience significant and dynamic idle intervals for many possible reasons. In a cloud environment, a large number of virtual machines run on a smaller number of physical hosts. Multiple virtual machines receive computing services from the same host via time or space sharing. A virtual machine typically receives a time slice of 30 -100 milliseconds from the host before switching to another virtual machine. This time is much longer than the CPU idle intervals that usually last from 10-500 microseconds. Therefore a lot of CPU idleness can be observed on cloud data center servers [11].

Recent studies identified that the server energy consumption scales literally with resource utilization. The data centers consume enormous amounts of electrical power resulting in high operational costs and carbon dioxide emissions. As cloud and green computing paradigms are closely related and they are gaining their momentum, energy efficiency of clouds has become one of the most crucial research issues. Huge amount of energy is consumed and dissipated while processing enormous tasks by the cloud data centers in execution on virtual machines. The cloud as well as grid based computing scenarios are susceptible to higher load and traffic of tasks. There is need to devise and implement the approaches which can optimize the energy with higher performance for overall effectiveness of the cloud environment.

As per research, there are many techniques which are being used to decrease the energy consumption in the mobile cloud data center. One of those techniques is the Virtual machine placement technique which is use in green cloud. Green computing offers schemes like load balancing across physical machines, live migration of virtual machines and Server Consolidation which aims at minimizing the number of Active Physical Machines (APMs). Virtualization enables sharing of computer hardware by partitioning the computational resources. In a data center server, often many services only need a small fraction of the total available resources. This can lead to a scenario in which several virtualized servers operate and consume a lot more space and resources than expected. So to prevent this problem of wastage of resources and to increase the energy efficiency, the virtualization technique is used with energy efficient dynamic resource scheduling. [10]. Virtualization technology allows one to create several Virtual machines on a physical server thereby reducing the amount of hardware in use. In data centers, the number of physical machines can be reduced using the virtualization by consolidating virtual machines onto shared servers which helps in improving the energy efficiency at the mobile cloud data centers. The three areas where energy is most consumed within a data center includes: (a) critical computational server providing CPU and storage functionalities; (b) cooling systems; (c) power conversion units [9].

B. *Virtual Machine Placement Algorithm*

The Virtualization technology allows one to create several VMs (virtual machines) on a physical server which hides the underlying computing system to present an abstract computing platform by using a hypervisor. It allows multiple virtual machines to be run on a single physical machine in order to provide more capability and increase the utilization level of the hardware. A hypervisor or virtual machine monitor (VMM) is run by each server or physical machine. The VMM like Xen, supports real time work environments of a single computer. Therefore each physical machine has multiple VMs running on it. All VMs are loaded by different cloudlets or tasks given by user. These cloudlets may be any application such as remote desktop, mail server, web server etc. All this information about the cloud data center is sent to a centralized VM scheduler, which implements green computing by adjusting the VM to physical machine mapping. The VM scheduler keeps a track of the available and allocated VMs, the history of VM resource demand, history of load on physical machine and the currently assigned VM physical mappings.

Fig 1**.** Algorithm for the Energy saving with the help of Virtualization

1. Activate Cloud Objects at server and User End Cloud Components
   a. Allocation Matrix
   b. Bandwidth Matrix
   c. Initial EnergyOptimizedValue Factor
   d. Data Centers
   e. VM
   f. Cloudlets
   g. Users
2. Amalgamation of security keys for Security and Integrity to improve the EnergyOptimizedValue Model and transmission initiates

3. Collection and Initialization of Training DataSets with dynamic initialization of the cloud elements for deep investigation and research
   a. Solution space (All EnergyOptimizedValue Values and individual score)
   b. Cost function (Directly proportional to the execution time and performance parameters c = 1/(r * (p + e)) * 100)
   c. Analysis of the acceptance value for the cost function
   d. Perturbation rules for Transforming a solution to a new one
   e. Solutions from one phase to other for higher degree of accuracy and integrtiy
   f. Simulated Annealing engine
      i. Activation of variable T (Temperature)
      ii. An initial temperature T_0 (T_0 = 50,000)
      iii. A freezing temperature $T_{freezing}$ ($T_{freezing}$= 0.1)
      iv. threshold=(0.05) 5% Rejection rate
4. A cooling schedule (T = 0.95 * T)
5. SA evaluation module for EnergyOptimizedValue value with binary permutations
6. Application of the proposed algorithmic approach and model on cloud elements for effective results
7. Fetching of Results and storage in the file system Data Cleaning, Analysis, Interpretation and Prediction.

C. *Simulation and Analysis*

To get access to cloud services, the cloud service providers charge depending upon the space or service provided to the client. In research and development, it is not always possible to have the actual cloud infrastructure for performing the experiments. For any research scholar, academician or scientist, it is not feasible every time to hire the cloud services and then executing their algorithms or implementations. For the purpose of research, development and testing, the open source libraries are available using which the feel of the cloud services and executions can be experienced. Now days, in research work, the cloud simulators are widely used by the research scholars and practitioners without paying any amount to any cloud service provider. Using cloud simulators, the researchers can execute their algorithmic approaches on a software based library and can get the results in different parameters including energy optimization, security, integrity, confidentiality, bandwidth, power and many others. In fig 2 there is shown response time of a task created in a virtual machine contained in the host of a mobile cloud data center and the whole process is carried out in the CloudSim simulator.

The classical algorithm that is the virtual machine placement technique doesn't generally yield the truly ideal solutions. In such cases the greedy strategy is as often as possible the premise of a heuristic methodology. Notwithstanding for issues which can be explained precisely by the existing algorithm, building up the strategy's accuracy may be a non-trifling procedure. It might frequently return off base results. It frequently requires next to no investment to do such.

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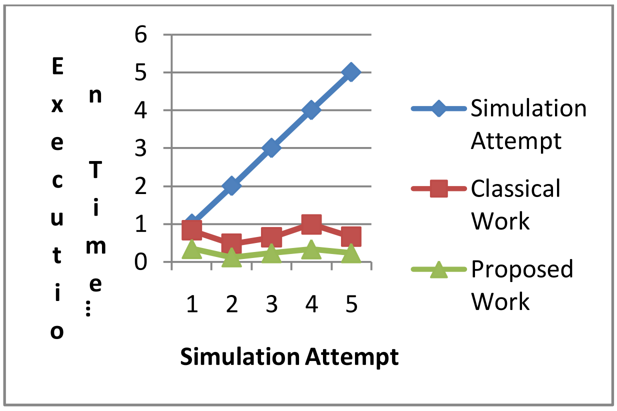

Fig 2. Comparison of the simulation results in classical and proposed approach

RFD is very new algorithm for optimization of results. Classically, In our case, the set of best cases for security test evaluation shall be considered as a River. In natural phenomena, the water comes from multiple direction mountains and then merges into the river. In this research work, each test case (water) will be generated from different mathematical functions (mountains). This process will continue till we get the best and optimal set (path of river) of test cases (free flowing water without leakage). Here, Leakage of Water is related to the Overlapping and Redundant Test Cases. Following are the graphs which are showing the comparison of various parameters in the existing technique based on the last job first problem and the first come first problem, both following the virtualization technique as mentioned above.

D. *Experimental Evaluation and Results*

The Classical or Existing Approach is not having effectiveness and efficiency as compared to RFD based approach. The classical work is taken as the implementation without integration of meta-heuristic based simulation. As it is shown in fig 3 there is huge difference in the performance of the virtual machine placement technique and the river dynamics approach. It deeply enhances the energy aware approach to a greater degree. The novel projected architecture is having a set of multiple layers which function in association with each other so that the higher degree of security and integrity can be maintained. In the fig 3 the cost factor is taken under consideration and then various simulation attempts have been put on for both the existing approach and the proposed approach and then the graph is plotted on the basis of the results from which it is known that the proposed approach that is the river dynamic approach have contributed more towards the energy efficient working of systems in the mobile cloud computing. In table 1 the values of cost factor parameter at both the approaches are listed to have a quick analysis of the simulation work.

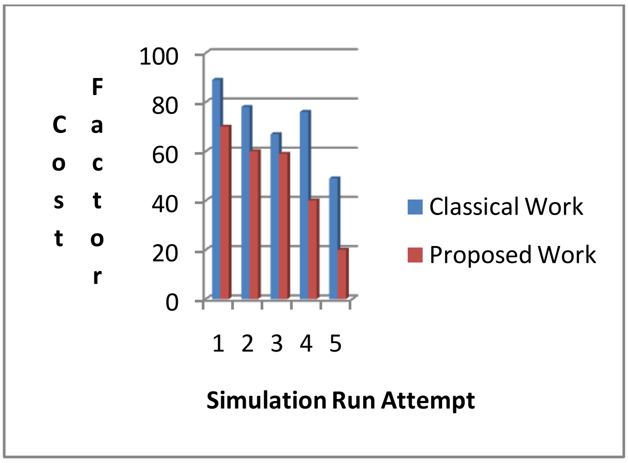

Fig 3. Comparison of classical and projected approach in terms of Cost

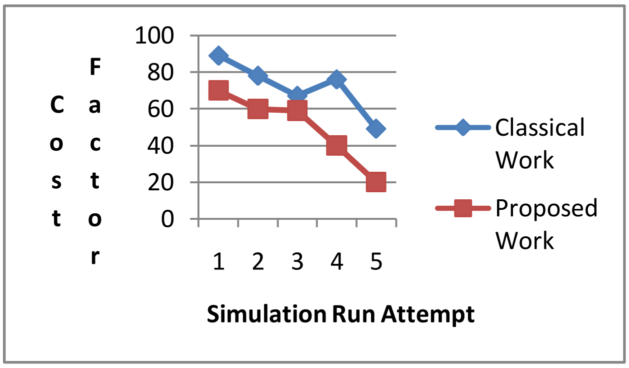

Fig 4. Simulation results in terms of cost

Higher degree of complexity because of increasing number of tasks at run time from multiple regions to the data centers whereas the proposed approach is using parallel approach by which the dynamic resource allocation is taking place in parallel. The classical approach is greedy based which is heuristic approach. By this approach the complexity is higher in most of the cases whereas the proposed approach is soft computing based which are very powerful in solving combinatorial optimization problems. Also the proposed approach gives the fuzzy implementations. Meta-heuristics are said to be high level procedures which coordinate simple heuristics such as local search, to find solutions that are of better quality than those found by simple heuristics done. River formation dynamics is very new algorithm for optimization of results. Classically, River is having a bulk of water that flow in a specific direction without leakage to different paths. In our case, the set of best cases for security test evaluation shall be considered as a River. In our research work, each test case (water) will be generated from different mathematical functions (mountains). This process will continue till we get the best and optimal set (path of river) of test cases (free flowing water without leakage). Here, Leakage of Water is related to the Overlapping and Redundant Test Cases.

Table 1. Comparison analysis based on Cost factor

Simulation Attempt	Classical Work	RFD
1	89	72
2	76	62
3	65	61
4	74	42
5	47	22

IV. Conclusion And Future Work

Various energy effective strategies should be implemented in data centers to make eco-friendly data centers. Energy saving strategies saves a sufficient amount of power and of course cut down the cloud footprint [4]. The experimental results have shown significant improvement in the response time, in the segregation of storage space, and energy conservation [19].Task consolidation particularly in clouds has become an important approach to streamline resource usage and in turn improve energy efficiency [27]. Based on the fact that resource utilization directly relates to energy consumption, there has been the development of two-energy conscious task consolidation heuristics. The cost functions incorporated into these heuristics effectively capture energy-saving possibilities. Of course, the reduction in the carbon footprint of clouds is another important spinoff [13][17]. In the techniques there are some tradeoffs when deeply surveyed. Owing to the workload variability and continuously changing demands of applications, there is a need to constantly optimize these VM placement algorithms [2]. The proposed work is proposed to give the effective results in terms of very less error rate and high efficiency in getting probability factor of more security till this work can be further enhanced using other optimization approaches [28]. The key demarcation line between soft computing and heuristics is that nearly all the implementation in soft computing makes search in search space in the span of solutions of problem. For the scope of future work, the integration of meta-heuristic and soft computing approaches can be used for higher degree of performance and efficiency on multi- dimensional perspectives.

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