IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 1, No 2, January 2012
ISSN (Online): 1694-0814
www.IJCSI.org

Design of Power Efficient Schema for Energy Optimization in Data Center With Massive Task Execution Using DVFS

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Abstract: The proposed system highlights a novel energy efficient technique by considering an entire datacenter using DVFS (Dynamic Voltage and Frequency Scaling). Unwanted power consumption was always a matter of concern from last 2 years for the administrators of datacenters. Therefore, a research trial in order to minimize the power consumption has become of the prominent concern in the area of cloud computing as it claims zero down-time as per Service Level Agreement. In this research work, we consider the case of multimedia video sharing web services, which we believe is frequently in top of the hit counter with millions of user sharing high size of video application, giving rise of power consumption from data center. The proposed system presents a unique provisioning technique which amalgamates the power factor with network resources. The simulation results also show that the system is successful in maintaining an equilibrium between power utilization at data center along with unit of task allocation processing.

Keywords: Energy consumption, Cloud Computing, Data center.

I. INTRODUCTION

The current research concern is the unwanted power utilized in data center which is exceptionally gaining attention of researchers with respect to scheduling of the computing resources. Not only this, the investment towards the services of cloud computing is very high [1]. Cloud computing assures virtually limitless computational resources to its users, while letting them pay only for the resources they actually use at any given time. Various cloud computing services such as Amazon EC2 [2] and Google App Engine [3] are designed to take benefit of the already existing infrastructure of their respective business which delivers computing services to users as a utility in a pay-as-you-go manner [4]. The different services facilitated by the cloud providers are Platform as a Service (PaaS), Infrastructure as a Service (IaaS), and finally Software as a Service (SaaS). In reality, Service providers make high-quality use of IaaS and PaaS for developing their services without consideration of physical hardware, while users also can access on-demand and pay-per-use services anywhere in Cloud computing. But one of major issue in datacenters found is to manage optimum energy usage in the systems. It was found that there is a consumption of 10 to 100 times high energy per square foot compared to distinctive office building for an average scale datacenters [5]. They can even consume as much electricity as a whole city [6]. The majority of energy consumption in datacenters approaches from computation processing, disk storage, network, and various types of cooling systems. In this research proposal, we will deploy virtual machine provisioning to analyze various energy processing functionalities along with their parameters. This can be one of the noteworthy technique in cloud computing for evaluation of energy models in Cloud computing. The concept of cloud computing guarantees Service Level Agreements (SLAs) between customers and Cloud suppliers with Pay-as-you-go mechanism which specify that the negotiated agreements as deadline. Therefore, every datacenters will attempt to minimize energy consumption without violating these SLAs. As various real-time applications will require deadline constraints, this research proposal will concentrate on power-aware real-time Cloud services, such as distributed image processing, realtime distributed databases, financial analysis and so on. The main contribution of this proposed system will be to give (i) analysis and in-depth study of real-time Cloud service with virtualization, and (ii) to probe various energy-aware virtual machine optimizing schemes based on Dynamic Voltage Frequency Scaling schemes (DVFS).

The main contribution of this paper is to highlight a novel provisioning methodology which amalgamates power efficiency along with network resources information. My previous work was much focus on analyzing power consumption in virtual machine as well as processing element with respect to SLA (Service Level Agreement). The work has also shown the comparative analysis of implication of DVFS as well as DVS (Dynamic Voltage Scaling) technique. This work is more stressed on larger scale i.e. datacenter using similar DVFS. The proposed system targets to maintain the equilibrium between the unit task accomplishment, task quality of server needs, requirements of the network resources, and the utilized power by the data center. It is also found that data with known task will require a less effective load towards the design of queue structure. For the purpose of experiment, a multimedia sharing web application is considered.

The remainder of this paper is organized as follows. Section II presents problem statement followed by related works in Section III. The proposed approach is discussed in Section IV. Section V will highlight the simulation results followed finally Section VI will conclude the research proposal.

II. PROBLEM DESCRIPTION

Majority of the prior research work done in the area of analyzing power utilization mainly concentrates on task scheduling in the center with respect to task allocation among the application servers [7], targeted power saving [8] or the criteria considering thermal factors [9]. The major research gap is that there are only few implementation work being carried out in past considering data centers, unwanted power consumption along with task provisioning. [10][11].

Cloud computing has been accounted for diversified emerging issues which is yet to be resolved. Unfortunately, the current potentials and capability of cloud computing has yet not been enhanced to cater the crucial scope of the usage. There are technical and nontechnical gaps. One of the most prominent issues is that although vision of cloud computing is to deploy at any location irrespective of time and devices, particularly in case of distributed system and existing clouds is reported to deliver very poor performance in applications. Any significant issue is the migration of data from client's infrastructure to clouds actually cost very high and it is also a time consuming process. Various legal restrictions are yet to be created for the acceptance of this new technology in socioeconomic market. In many data centers today, the cost of power is only second to the actual cost of the equipment investments. Today the cloud data center consumes 1-2 percent of world energy. If left unchecked, they will rapidly consume an ever-increasing amount of power consumption.

III. RELATED WORK

Suzanne [12] propose and motivate JouleSort, an external sort benchmark, for evaluating the energy efficiency of a wide range of computer systems from clusters to handhelds. Since JouleSort focuses on data management tasks, it misses some important energy-relevant components for multimedia applications. JouleSort omits displays, which are an important component of total power for mobile devices. Anand Vanchi [13] developed methods for identifying measurable efficiency improvements and placed instrumentation to continuously track power usage effectiveness (PUE), the key metric of data center energy efficiency. Anshul [14] presents a novel approach to correctly allocate resources in data centers, such that SLA violations and energy consumption are minimized. Dara Kusic et. al. [15] implement and validate a dynamic resource provisioning framework for virtualized server environments wherein the provisioning problem is posed as one of sequential optimization under uncertainty and solved using a look ahead control scheme. A new suite for placement and energy consolidation of the virtual machines in data centers has been discussed by Michael Cardosa [16]. The author has validated the results obtained from experiments conducted in artificial and real data centers testbeds and concluded that the protocol designed constantly provides the optimal throughput on a large spectrum of inputs. A unique design and accomplishment of an architecture for managing resources over the hosting center operating system has been proposed by Jeffrey S. Chase [17]. The prime importance of the work was the power for running the resource management problems for huge clusters of servers intended to provide automation in adapting to prescribed load for server resources. This has resulted in enhancement of the power efficiency for clusters of server by resizing the set of active servers dynamically and reacting to the supply of energy interference or thermal events by corrupting the service as per Service Level Agreements (SLAs).

A power-aware protocol which automatically acclimatizes its potential difference and frequency configuration is already proposed by Chunghsing Hsu [18]. The main intention is to facilitate considerable reduction in energy and power cutback with optimal effect on its respective performance. Kyong Hoon Kim [19] proposed power-aware scheduling algorithms for bag-of-tasks applications with deadline constraints on DVS-enabled cluster systems. The proposed scheduling algorithms select appropriate supply voltages of processing elements to minimize energy consumption. Linwei Niu [20] investigated the problem of applying scheduling techniques to reduce both the dynamic and leakage energy consumption. Monfort [21] proposed a hierarchical real-time virtual resource model which is ideal for the open system environment with a clean separation of concerns between task group scheduling and partition scheduling across multiple levels of resource decomposition. Anshul Gandhi [22] experimentally find that the power-to-frequency relationship within a server for a given workload can be either linear or cubic. Interestingly, we see that the relationship is linear for DFS and DVFS when the workload is CPU bound, but cubic when it is more memory bound. By contrast, the relationship for DVFS+DFS is always cubic in their experiments. Leping Wang [23] presents a threshold-based method for efficient power management of heterogeneous soft real-time clusters. An illustrative analysis for recognizing the environment for isolative applications was studied by Akshat Verma [24]. The author has also shown that energy utilization by various HPC applications can be dependent on application or non-linear and can posses huge diversified range. The inter-association of power utilization and workload performance has been analyzed by Shekhar Srikantaiah [25] which elicited the power performance trade-offs for consolidation and concludes that superior operating point do persists.

IV. PROPOSED SYSTEM

The proposed technique attempts to reduce the cumulative power utilization of a specified data center which is done by choosing the suitable evaluating resources for task processing depending on the load quantity and transmission capability of the variants of data center specified. The transmission capability will be represented by available bandwidth facilitated to the unique application servers or clusters of servers. The proposed technique designs a architectural framework possessing the better designed topology of data center. The weighted grouping of the server level W_s, rack level W_r, and module level W_m is given by,

$$\text{Weighted Grouping} = P\,.Ws + Q.\,W_r + R.\,W_m. \quad (1)$$

Where P, Q, and R are the weighted coefficients factors. The allocation of higher set of load towards the server is preferred if the value of P is very high. Similarly, priority will be designed higher for higher set of task in the racks with reduced traffic events when the value of Q is higher. The selection of loaded modules will be preferred if value of R is higher. For understanding the magnitude of the task allocation in datacenter, the value of R plays an important role. The implementation plan of the proposed system is as shown in Fig 1.

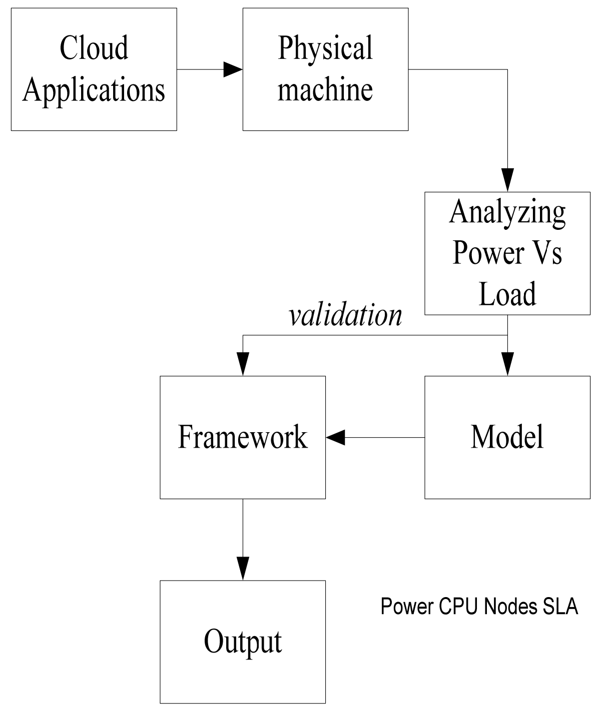

Fig 1. Implementation Plan

The selection of the operationally processing server will group the server load $S_L(l)$ along with its transmission capability $T_C(q)$ which is analogous to equivalent distribute of the uplink resources on the top of rack switch.

$$W_s(l,q) = S_L(l).\frac{T_C(q)^{\varphi}}{\Delta_r} \quad (2)$$

In the above equation, $S_L(l)$ is a parameter which is proportional to the load of any individual servers l, $T_C(q)$ which represents the load at the rack uplink by evaluating the traffic blocking intensity in the designed queue q, Δ_r is a bandwidth over scheduled parameter at the rack switch and φ will represent a coefficient for share between $S_L(l)$ and $T_C(q)$. It is also known that both $S_L(l)$ and $T_C(q)$ should lie within a range (0,1) greater value φ will reduce the significance of network variants $T_C(q)$. Therefore, with context to the equation (2), the criteria having influencing the rack switch can be expressed as:

$$W_r(l,q) = S_R(l).\frac{T_m(q)^{\varphi}}{\Delta_m} = \frac{T_m(q)^{\varphi}}{\Delta_m}.\frac{1}{n}\sum_{i=1}^{n} S_L(l) \quad (3)$$

$$W_m(l) = S_m(l) = \frac{1}{k}\sum_{j=0}^{k} S_R(l) \quad (4)$$

In the equation (4), $S_R(l)$ is a load on rack which is derived from the addition of all the component loads on server in the rack, $S_M(l)$, is the module load derived as the normalized addition of all of the loads in rack in this module, n and k are quantity of the servers in a rack and the quantity of the racks in the module respectively, $T_C(q)$ is dependent to the network load at incoming networking devices and Δ_m will represents channel capacity as over scheduled criteria at the module switches. It can be seen that module level criteria Fm will posses only components *l* related to load. This phenomenon is due to the reason that all the components are actually associated to the uniform networking device and split the similar channel capacity by deploying a technique which can work on unit load balancing resulting in discretion of traffic flows by estimating a hash function on all ingress message. It was also noted that idle server in data center consumes 2/3rd of its crest utilization [26] which concludes that if any provisioner is to be designed that it must merge all the allocated task on a minimum feasible group of computing resources. Also, it should be noted that if the application servers are kept in uniform execution mode at high frequency than hardware reliability along with its performance will be not so much effective. Therefore, the proposed load criteria is designed as following:

$$S_L(l) = \frac{1}{1+e^{-10(l-\frac{1}{2})}} - \frac{1}{1+e^{-\frac{10}{\varepsilon}(l-(1-\frac{\varepsilon}{2}))}} \quad (5)$$

The preliminary component as shown in equation (5) explains the data-structure of the function while the 2nd variant denotes the fining method targeted at the junction towards the highest load of the server.

The factor ε represents the dimension and the shift of the descent slope. The load of application server *l* should be in constraint of (0,1). In case of highly dynamic load towards server, the load on application server will be evaluated as the total of all processing load of the allocated present task. But in case of jobs where the deadline is fixed for completion, the load on the server can be represented as the least quantity of the networking resources which will be required from the application server to accomplish all the jobs at pre-defined time as per SLA. In datacenter, the application server will split the top of rack switch for meeting their transmission requirements. Conversely, representing a section of this channel capacity utilized by a specified application server or a transmission at higher frequency deployed in defined server during execution will be definitely highly expensive in terms of processing the algorithm. In order to mitigate such issues, using eq 3 and 4 will use a variant based on the task allocated stage of the job-queue at the networking device and levels the channel capacity over scheduling criteria Δ.

As an alternative of depending on the appropriate queue size, the allocation stage q will be leveled with the cumulative queue size T_{max} within the range of (0,1). The variety is analogous to void and complete buffer allocation. By depending on the buffer allocation, the proposed system will be responsive to the increasing blocking in the racks moderately in comparison to rate of transmission differences. Therefore T(q) will be represented as:

$$T(q) = e^{-(\frac{2q}{T_{max}})^2} \quad (6)$$

V. SIMULATION RESULT

The proposed system discussed is evaluated on java platform in 32 bit machine with windows OS of 1.84 GHz processor. The prototype design of DVFS protocol is layered into task-allocation, group creation, and processing elements. The virtual machines are developed for accepting number of task considering simulation time and processing speed of the system. The framework is developed to track down the communication in datacenter. The optimization is checked through JOULEX [27]. The application server is taken for YOUTUBE [28] as normally multimedia applications are heavy, frequently visited, and has sharing privileges for the users..

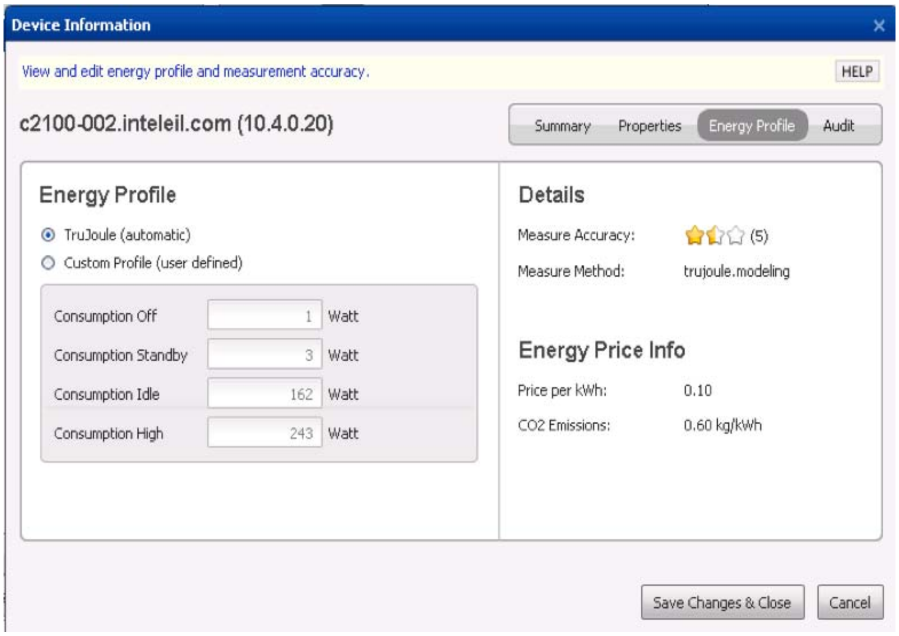

Fig 2. Joulex Interface

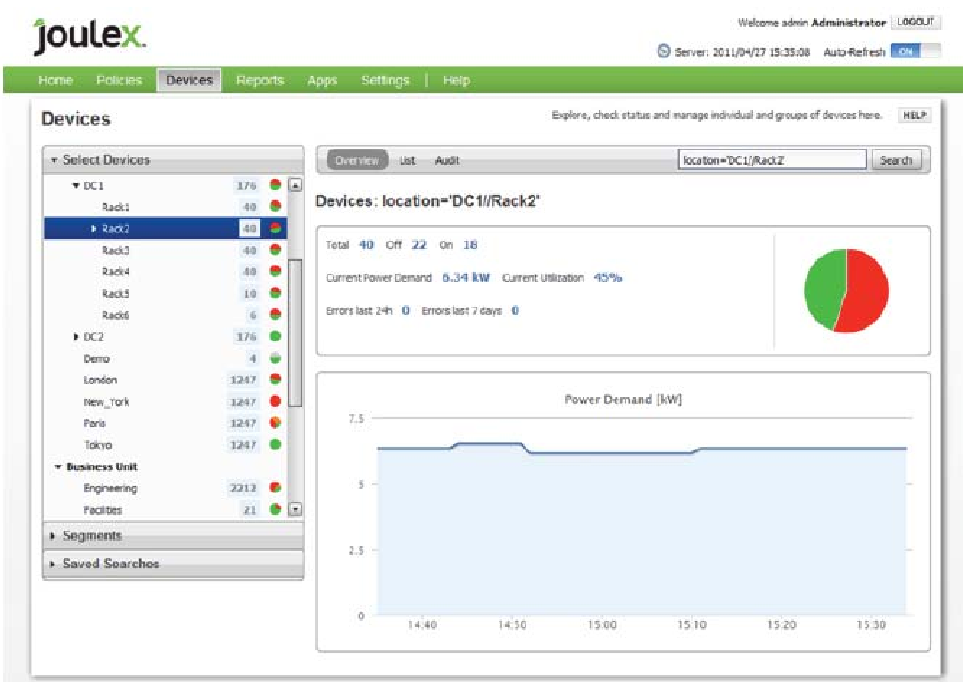

Fig 3. Joulex interface with graphical representation of Power consumption

The proposed system performs implementation of our proposed DVFS scheme along with traditional DVS scheme, where we consider both the schemes for energy optimization for the datacenters along with all its components. The considerations are:

No of server=1536
No. of Racks=32
No of application server by racks=48
Propagation delay on links=10 ns
Experiment Task size=15 KB

A communication link is created for connecting application server within the rack. The total set of work is exponentially dispersed to the executers.

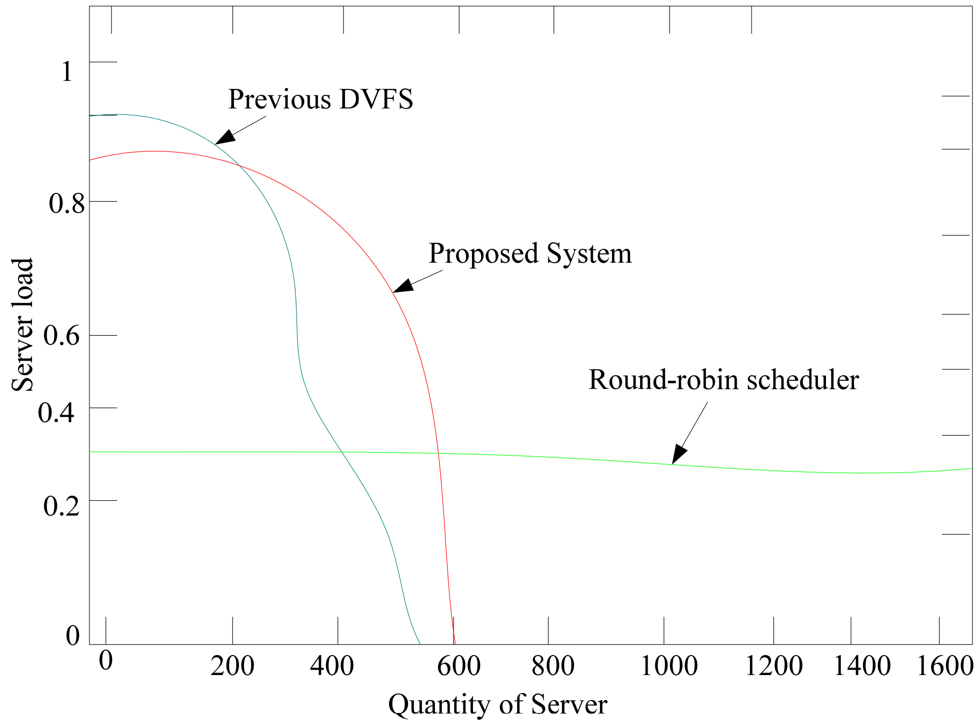

Figure 4. Server workload distribution performed by proposed system, previous DVFS implementation, and round-robin technique

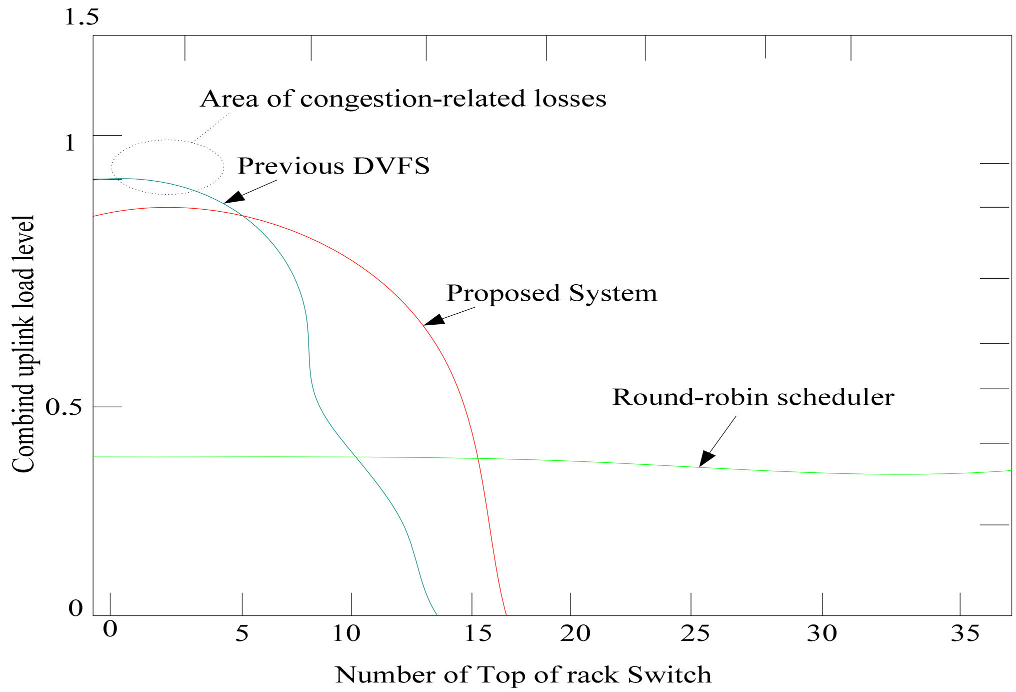

Figure 5. Joint uplink traffic load

Once the provisioning decision is undertaken for a recently designed task, it will be forwarded to the point of datacenter to the chosen application server for the purpose of execution. At the processing mode, the task generates a uniform stream of bitrate of 1.6 Mb/s which is forwarded to the datacenter.

To increase the challenges at the simulation time, each of the task communicates with another task which is arbitrarily chosen by transmitting a dummy message of 125 KB implicitly. Also at the event of task accomplishment, the similar size packets will be forwarded to the datacenters. The mean task load in the datacenter is fixed to 45% which is dispersed among other application server. A round robin algorithm can be used for this purpose.

The proposed algorithm is experimented with the previously implemented DVFS techniques as well as conventional round robin algorithm. The comparative analysis is presented in fig 4 and fig 5. Fig. 4 represents the load allocation to Server for all the analyzed provisioner and Fig 5 represents a Joint uplink traffic load.

VI. CONCLUSIONS

The proposed system identifies the function of transmission structure in the datacenter power utilization and highlights a unique process which amalgamates the power with network resources. The proposed system maintains the equilibrium for the unique task processing and accomplishment, power utilization of the data center, and optimal network requirements. The system has optimized the research gap for task grouping for reducing the quantity of the application server in the data center and dispersing of the network resources in order to mitigate the congestion which might possible occur in data center leading to unwanted power consumption.

Reference

[1] R. Brown et al., “Report to congress on server and data center energy efficiency: Public law 109-431,” Lawrence Berkeley National Laboratory, 2008.
[2] “Amazon Elastic Compute Cloud,” http://aws.amazon.com/ec2.
[3] “Google App Engine,” http://code.google.com/appengine/.
[4] M. Armbrust, et al. Above the Clouds: A Berkeley view of cloud computing. Tech. Report No. UCB/EECS-2009-28, University of California at Berkeley, USA, February 2009
[5] P. Scheihing. Creating energy efficient data centers. In Data Center Facilities and Engineering Conference. Washington, DC, USA, May 2007.
[6] J. Markoff and S. Lohr. Intel’s huge bet turns iffy. New York Times Technology Section, September 2002.
[7] Ying Song, Hui Wang, Yaqiong Li, Binquan Feng, and Yuzhong Sun, “Multi-Tiered On-Demand Resource Scheduling for VM-Based Data Center,” IEEE/ACM International Symposium on Cluster Computing and the Grid (CCGRID), pp. 148 – 155, May 2009.
[8] A. Beloglazov, and R. Buyya, “Energy Efficient Resource Management in Virtualized Cloud Data Centers,” IEEE/ACM International Conference on Cluster, Cloud and Grid Computing (CCGrid), pp. 826 –831, May 2010.
[9] Qin Tang, S. K. S. Gupta, and G. Varsamopoulos, “Energy-Efficient Thermal-Aware Task Scheduling for Homogeneous High-Performance Computing Data Centers: A Cyber-Physical Approach,” IEEE Transactions on Parallel and Distributed Systems, vol.19, no. 11, pp. 1458 – 1472, November 2008.
[10] M. Al-Fares, S. Radhakrishnan, B. Raghavan, N. Huang, and A. Vahdat, “Hedera: Dynamic Flow Scheduling for Data Center Networks,” in Proceedings of the 7th USENIX Symposium on Networked Systems Design and Implementation (NSDI '10), San Jose, CA, April 2010.
[11] Xiaoqiao Meng, V. Pappas, and Li Zhang, “Improving the Scalability of Data Center Networks with Traffic-aware Virtual Machine Placement,” IEEE INFOCOM, San Diego, California, March 2010.
[12] Suzanne Rivoire, Mehul A. Shah, Parthasarathy Ranganathan, Christos Kozyrakis, JouleSort: A Balanced Energy-Efficiency Benchmark, Proceedings of the ACM SIGMOD Intl. Conference on Management of Data (SIGMOD), Beijing, China, June 2007.
[13] Anand Vanchi, Sujith Kannan, and Ravi Giri, Increasing Data Center Efficiency through Metering and Monitoring Power Usage, White Paper, 2009
[14] Anshul Gandhi, Yuan Chen, Daniel Gmach, Martin Arlitt, Manish Marwah, Minimizing Data Center SLA Violations and Power Consumption via Hybrid Resource Provisioning, IEEE, 2010
[15] D. Kusic, et al. Power and performance management of virtualized computing environments via lookahead control. In Proc. of 5th IEEE Intl. Conf. on Autonomic Computing (ICAC 2008), pages 3–12. Chicago, USA, June 2008.
[16] M. Cardosa, M. R. Korupolu, and A. Singh. Shares and utilities based power consolidation in virtualized server environments. In Proc. of

IFIP/IEEE Intl. Symp. On Integrated Network Management. USA, June 2009.
[17] J. S. Chase, et al. Managing energy and server resources in hosting centers. In Proc. of 8th ACM Symp. on Operating Systems Principles. Banff, Canada, October 2001.
[18] C. Hsu and W. Feng. A power-aware run-time system for high-performance computing. In Proc. of ACM/IEEE Conf. on Supercomputing. Seattle, USA, November 2005.
[19] K. H. Kim, R. Buyya, and J. Kim. Power aware scheduling of bag-of-tasks applications with deadline constraints on DVS-enabled clusters. In Proc. of 7th IEEE Intl. Symp. On Cluster Computing and the Grid (CCGrid'07), pages 541–548. Rio de Janeiro, Brazil, May 2007.
[20] L. Niu and G. Quan. Reducing both dynamic and leakage energy consumption for hard real-time systems. In Proc. Of CASES'04. Washington, DC, USA, Sept. 2004
[21] Valérie Monfort, Maha Khemaja, Nouha Ammari, Fayssal Fehli, Using SaaS and Cloud computing For "On Demand" E Learning Services, 2010 10th IEEE International Conference on Advanced Learning Technologies
[22] A. Gandhi, M. Harchol-Balter, R. Das, and C. Lefurgy. Optimal power allocation in server farms. In Proc. of Intl. Joint Conf. on Measurement and Modeling of Computer Systems, pages 157–168. Seattle, USA, June 2009.
[23] L. Wang and Y. Lu. Efficient power management of heterogeneous soft real-time clusters. In Proc. of IEEE Real-Time Systems Sym. Barcelona, Spain, Dec. 2008.
[24] A. Verma, P. Ahuja, and A. Neogi. Power-aware dynamic placement of HPC applications. In Proc. of ICS'08, pages 175–184. Agean Sea, Greece, June 2008.
[25] S. Srikantaiah, A. Kansal, and F. Zhao. Energy aware consolidation for cloud computing. In Workshop on Power Aware Computing and Systems (HotPower '08). San Diego, USA, December 2008.
[26] G. Chen, W. He, J. Liu, S. Nath, L. Rigas, L. Xiao, and F. Zhao, "Energy-aware server provisioning and load dispatching for connection intensive internet services," the 5th USENIX Symposium on Networked Systems Design and Implementation, Berkeley, CA, USA, 2008.
[27] http://www.joulex.net/.
[28] http://www.youtube.com