ISSN: 2277-9655
(I2OR), Publication Impact Factor: 3.785

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

REDUCING COST OF POWER CONSUMPTION USING GOAL PROGRAMMING OPTIMIZATION AND RENEWABLE ENERGY SOURCE

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ABSTRACT

The demand of cloud computing grows rapidly with the rapid increase in IT infrastructure. Cloud computing now a day, are widely used by industry, organization and society to deliver IT services. This rapid growth leads to the creation of large data centers. These data centers requires enormous amount of electrical power for its operation and thus, result in high operational cost and carbon-dioxide emission. In this work the key idea is to reduce the requirement of power consumption by efficient task allocation and its cost. Datacenters are connected to conventional power grid as well as to renewable energy source. We performed this work in two phases: first used goal programming optimization for energy efficient task allocation to reduce power consumption and then analyzed the reduction in cost if we use RES for power supply. We used solar power panel as renewable energy source and analyzed the significant reduction in cost.

KEYWORDS: Green computing, Goal Programming, Energy Efficient Task Allocation, Solar Power Panel.

INTRODUCTION

In cloud computing virtualization technology is one of the fundamental components. It creates secure, isolated and customizable execution environment for running application, even if they are un-trusted, without affecting other user's applications. Virtualization is a fast growing infrastructure in the IT industry. It represents the logical view of data representation the power to compute in a virtual environment, storing data at different geographies, and availing various computing resources. There are many open challenges, related to energy- efficient management of datacenters and the marketplace for cloud computing.

The need to manage multiple applications in a datacenter creates great challenge for on-demand resource provisioning and allocation in response to time-varying workloads. Until recently, high performance has been the sole concern in datacenter deployments, and this demand has been fulfilled without paying much attention to energy consumption. Because energy costs are increasing while availability dwindles, there is a need to shift focus from optimizing datacenter resource management for pure performance alone to optimizing for energy efficiency while maintaining high service-level performance.

Datacenters are not only expensive to maintain, they are also unfriendly to the environment. Carbon emissions due to datacenters worldwide are increasing rapidly. High energy costs and huge carbon footprints are incurred due to the massive amount of electricity needed to power and cool the numerous servers hosted in these datacenters. Cloud service providers need to adopt measures to ensure that their profit margins are not dramatically reduced due to high energy costs [1].

So, in order to reduce high energy cost and carbon-dioxide emission we used solar power panel to meet the energy demand of datacenters. The benefit of using solar system is that it requires initial investment and deployment but has very low maintenance cost.

In this paper we performed goal programming optimization for energy efficient VM allocation. Through optimization we obtain the energy demand and matched it with the RES power supply in order to reduce the operational cost and CO2.

GREEN COMPUTING

Our work is based on Green computing. The term combines the words green meaning environmentally friendly and cloud, the traditional symbol for the Internet and the shortened name for a type of service delivery model known as cloud-computing.

According to market research conducted the wide-spread adoption of cloud computing could lead to a potential 38% reduction in worldwide data center energy expenditures by 2020. The savings would be primarily achieved by data center consolidation and maximizing power usage efficiency, improving recycling efforts, lowering carbon and gas emissions and minimizing water usage in cooling the remaining centers.

The goals of green computing are to reduce the use of hazardous materials, maximize energy efficiency during the product's lifetime, and promote the recyclability of defunct products and factory waste. Green computing is important for all classes of systems, ranging from handheld systems to large-scale data centers.

LITERATURE SURVEY

There has been a lot of work on VM allocation in cloud computing environments. However, to the best of my knowledge, this work is the first to deal with the problem of VM allocation under solar power supply to reduce the cost of electric power supply from conventional grid.

In work [5] they said Solar energy prediction is typically obtained with estimated weighted moving average (EWMA) models, because of its relative consistency and periodic patterns. As long as the weather conditions remain consistent within a period, the prediction is accurate, but becomes inaccurate, with mean error over 20%, with frequent changes in weather. In work [6] they utilize small-scale solar generation and used weather conditioned moving average (WCMA). They took into account the mean value across days and a measured factor of solar conditions in the present day relative to previous days. While this work provides only a single future interval of prediction, it specifically addresses inconsistent conditions, with a mean error of under 10%.

In the work [7] they performed Dynamic VM allocation in Cloud Server Facility with RES. In order to test their algorithm they used real data traces. In case of wind-turbine generation, they used data from [8] and for solar panel generation they use a Gaussian-shaped function with peak at mid-day. They assume that the arrival rate for VM executing dynamically changes per hour and use normalized values from [9] as arrival rate. Their work depicts the reduction of power cost as the length of the look-ahead window increases. A different line of works is [10], which focuses on reducing the electricity bill of commercial web search engines operating on data centers that are geographically far apart. To achieve that, the authors propose a technique based on the observation that energy prices and query workloads show high spatiotemporal variation. In addition, the authors of [11] and [12] evaluate the impact of geographical load balancing, the optimal mix of RESs and the role of storage in order to investigate the feasibility of powering internet-scale systems using entirely renewable energy.

SYSTEM MODEL

We are considering multiple cloud server facilities. Each cloud server facilities are connected to renewable energy source for the power supply as well as to the conventional power grid.

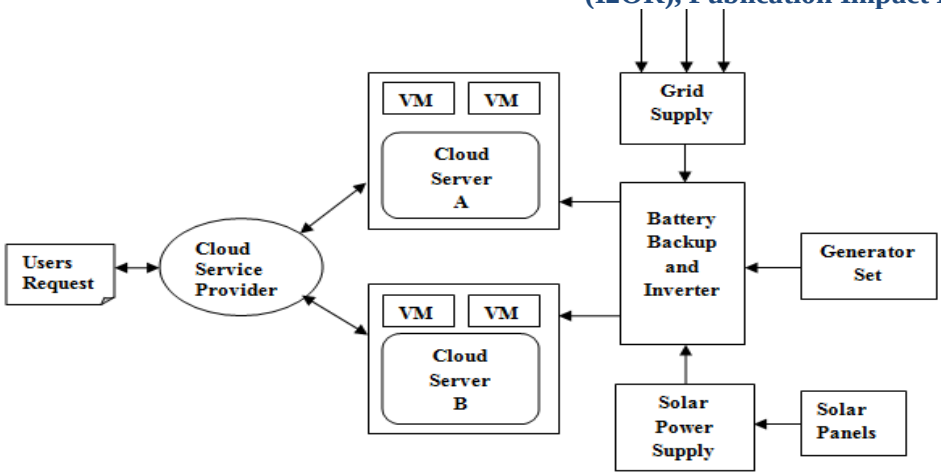

Figure 1: System Architecture

As shown in Figure: 1, the users requests first arrives at the central cloud service provider with the required resource requirement , which then create the virtual machine and allocate them to the cloud server. The set of VMs executing tasks at the servers needs power for their operations. The power demand is then fulfilled by solar power panel and if required through the main grid. In case grid power fails we attached batteries and generator sets to the solar panel for continuous power supply.

In this work we tried to reduce the power consumption and fulfill the energy demand through solar power panel. In case of less power supply due to weather condition we fulfill the power demand through main grid. In this a way we tried to reduce the cost of power and the emission of carbon-dioxide due to heat.

PROPOSED SYSTEM

We performed our work in two phases: in first phase we proposed goal programming optimization for efficient VMs allocation and compared its result with online greedy algorithm and in second phase we analyzed reduction in power cost if we use solar power system to meet the energy demand.

A. GOAL PROGRAMMING

In cloud computing, there are many datacenters that are used to serve customers need. Datacenters consists of number of servers and each server runs number of VM. Different VMs have different capacity to execute tasks with different QoS parameter. Thus, energy efficient VM allocation is necessary for efficient tasks execution which results in less operational cost and CO2 emission. We used Goal programming optimization to achieve this purpose.

Cloud service provider when receives user requests first estimate the required capacity of the virtual machine based on the resource requirement as our goal for efficient execution of the task. It then sorts the VMs according to their capacity and allocates the task to it. Service provider then allocate the VMs to the cloud server suitable for executing the tasks. For simulation we used cloudsim toolkit. CloudSim is used as an extensible simulation toolkit that enables modeling and simulation of Cloud computing systems and application provisioning environments. The set of VMs under execution at a particular server form the server load and affect the power consumption of the components of that server, and primarily the portion of power consumed for the CPU utilization. Our system consists of a cloud provider that owns a multiple cloud server facilities and exposes this infrastructure to clients which do not have the resources to execute their tasks. Whenever a client asks for resources, the cloud provider creates a VM and selects one of his cloud server facilities to host it as shown in Figure 1.

In case of multiple cloud server facilities we used assignment value x_{ij} indicating the selection of cloud server i to execute the virtual machine j. Each VM is assigned to one cloud server facility based on the assignment value and the assignment value is described as:

$$x_{ij} = \begin{cases} 1 \; if \; VM \; j \; is \; assigned \; to \\ cloud \; server \; facility \; i \\ 0 \; otherwise \end{cases}$$

Consider the set of request $r = \{1, 2, \ldots \ldots, n\}$ arrives at cloud service provider with resource requirement. We need to find the start execution time s_j, the running time T_j and the processing capacity c_j for each created virtual machine. Each created virtual machines are than sorted based on their capacity for efficient task execution. Find the task to allocate to virtual machine so that power consumed by the data center can be minimized:

$$\min \sum_{i=1}^{n} \sum_{j=1}^{m} P_{ij} x_{ij},$$

where

$$i = 1,2, \ldots., n \; and \; j = 1,2, \ldots., m,$$

subjected to

$$x_{ij} \in (0,1),$$

B. SOLAR POWER PREDICTION

Today, lifestyle is changing at a very fast pace. People are accepting various ways to save energy. Solar power is one of them through which we can achieve our purpose. Solar power system provides various benefits over grid electricity both economically and environmentally. The government has taken initiatives to promote the installation of solar power panel by allowing the sale of energy generated by system. This has created the commercial sense of solar power.

The cost per watt of energy from solar system reduces considerably with the reduction in cost per watt of the inverter. It also provide the benefit of net-metering, giving you a return of about 20 per cent annually for 20 years, depending upon per unit cost of the energy generated and the load used. The cumulative cash flow is calculated assuming that the grid tariff will increase at the rate of 5% per year. Whereas the solar tariff will rise at 2% or remain same, in which 30% cost of the system is paid upfront. We have taken Rs. 7.75 per unit cost of the grid electricity from the LT tariff booklet.

RESULT ANALYSIS

To assess the performance of our proposed work we compared our result with the online greedy algorithm. Result shows the significant reduction in cost as shown in Figure: 2.

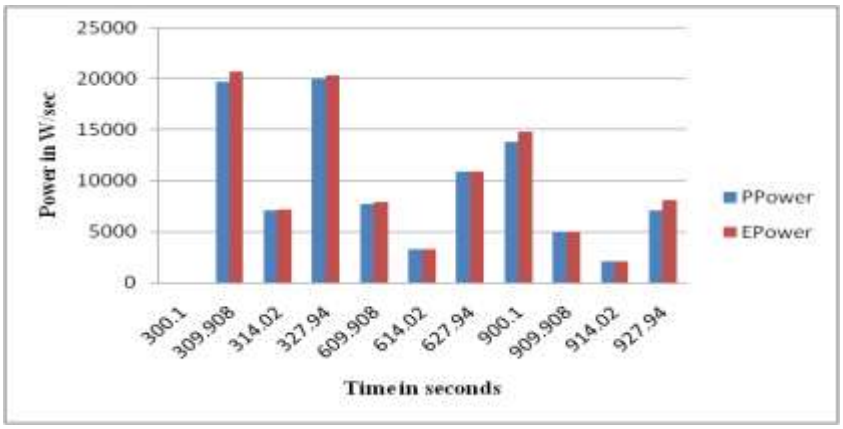

Figure 2: Comparison Of Power Consumption

Table 1, shows that VM allocation using goal programming optimization result in less power consumption.

Table 1: Power Consumption

Time (seconds)	Proposed Method Power Consumption (W/sec)	Existing Method Power Consumption (W/sec)
300.1	0	0
309.908	19702	20702
314.02	7103	7203
327.94	20119	20319
609.908	7728	7928
614.02	3239	3239
627.94	10952	10952
900.1	13815	14815
909.908	4999	4999
914.02	2096	2096
927.94	7098	8108

Efficient VM allocation leads to better resource utilization. Thus, result in reduced operational cost as shown in Table 2.

Table 2: Cost Comparison

Time (seconds)	Proposed Method Cost (Rs.)	Existing Method Cost (Rs.)
300.1	637.53	766.66
15600.1	467.201	681.504
20409.9	574.51	579.31
27627.9	467.201	473.71
31800.1	190.08	681.504
36927.9	574.51	766.66
40827.9	467.201	681.504
45900.1	190.08	511.18
48927.9	637.53	766.66
52800.1	467.201	681.504
56400.1	190.08	511.18
59700.1	637.53	766.66
63327.9	467.201	681.504
66327.9	574.51	426.02
82500.1	467.201	511.18

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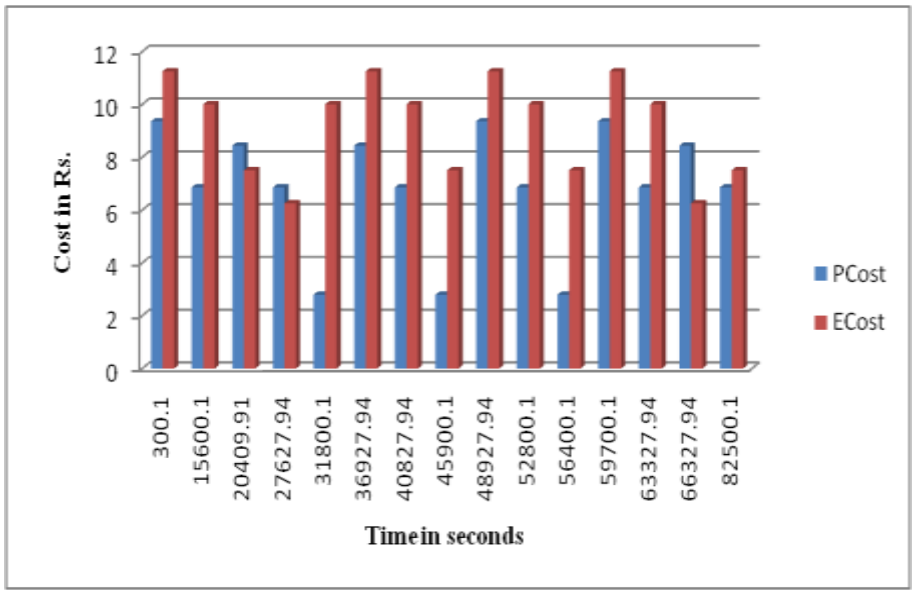

Figure 3: Comparison of Cost

We then estimated the reduction in the cost of power using solar power panel. Solar power systems provide the benefit of net-metering. As shown Table 3, if we use solar panel for the power supply it only requires initial investment and provides benefit of long provision of energy.

Table 3: Cumulative Cash Flow

Cost (Rs.)	Year
-1.94 L	2016
-1.50 L	2017
-1.07 L	2018
-6.34 L	2019
-1.89 L	2020
2.68 L	2021
7.3 L	2022
1.19 L	2023
1.67 L	2024
2.15 L	2025
2.64 L	2026
3.14 L	2027
3.64 L	2028
4.15 L	2029
4.67 L	2031

5.20 L	2032

Moreover, as shown in Figure 4, in 4-5 years the whole amount will get recovered and after that electricity will be free. This will greatly reduce the power supply cost for the operation. Table 3, shows the cumulative cash flow while using the solar power system.

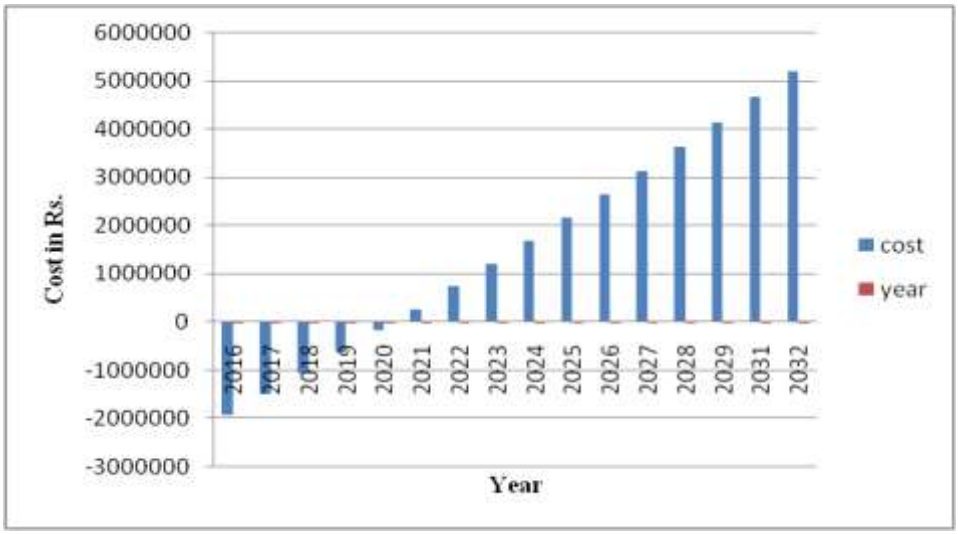

Figure 4: Cumulative Cash Flow

CONCLUSION AND FUTURE WORK

We studied the problem of virtual machine allocation in a set of cloud server facilities. We proposed goal programming approach in which we are allocating the task to the virtual machine in such a way that the load can match with the RES power. And if in any case VM load exceeds the power supplied by the renewable source, we can draw the power from main grid. The solution provided by the proposed technique is then compared with online greedy algorithm. The simulation results confirm superior performance of the proposed scheme in terms of reduction in operation cost. Then based on the power demand we estimated the future scenario of solar power panel, the results shows that solar makes great sense and high saving as compared to grid.

In the future we plan to focus on defining more detailed model that capture possible multi-tenancy and other realistic phenomena encounter in the cloud.

REFERENCES

[1] Rajkumar Buyya, Christian Vecchiola and S. Thamarai Selvi, "Mastering Cloud Computing", 2013.
[2] J. Tanega. Towards Cooperative Grids: Sensor/Actuator Networks for Renewables Integration. Sensys 2010 Doctoral Colloquium. 2010.
[3] B. Watson, A. Shah, M. Marwah, C. Bash, R. Sharma, C. Hoover, T. Christian, C. Patel. Integrated Design and Management of a Sustainable Data Center. *Proceedings of IPACK2009*. 2009.
[4] A. Krioukov, C. Goebel, S. Asplaugh, Y. Chen, D. Culler, R. Katz. "Integrating Renewable Energy Using Data Analytics Systems: Challenges and Opportunities". *IEEE Data Engineering Bulletin. March 2011.*
[5] C. Holt. Forecasting seasonal and trends by exponentially weighted moving averages. *International Journal of Forecasting*, 2004.
[6] J. Piorno, C. Bergonzini, D. Atienza, T. Rosing. Prediction and management in energy harvested wireless sensor nodes. University of California, San Diego, 2010.

[7] Dimitris Hatzopoulos, Iordanis Koutsopoulos, George Koutitas and Ward Van Heddeghem, *"Dynamic Virtual Machine Allocation in Cloud Server Facility Systems with Renewable Energy Sources"*. s.l. : IEEE ICC- Selected Areas in Communications Symposium, 2013.
[8] "Centre for renewable energy sources and saving." http://www.cres.gr/ kape/index gr.htm.
[9] S. Kandula, S. Sengupta, A. Greenberg, P. Patel, and R. Chaiken, "The nature of datacenter traffic: Measurements and analysis," in *Proc. ACM IMC*, 2009.
[10] E. Kayaaslan, B. Cambazoglu, R. Blanco, F. Junqueira, and C. Aykanat, "Energy price-driven query processing in multi-center web search engines," in *Proc ACM SIGIR*, 2011.
[11] Z. Liu, M. Lin, A. Wierman, S. Low, and L. Andrew, "Geographical load balancing with renewables," in *Proc. ACM SIGMETRICS*, 2011.
[12] Z. Liu, M. Lin, A. Wierman, S. Low, and L. H. Andrew, "Greening geographical load balancing," in *Proc ACM SIGMETRICS*, 2011.