Intelligent Power Management of Data-centers using Machine Learning Techniques

ABSTRACT

It is said that Data Centers are answerable for 2% of the CO2 emissions across the global number par to the aviation industry. The data-centers are consisting of various computing systems and servers, having different performance profiles, which poses a challenge to job schedulers and utilization of the entire capacity of the virtual machines running on them to achieve the best usage of the infrastructure. The main aim of this paper is to consider energy consumption and data-centers performance in order to evaluate, analyze and present them since there is an increase of consumption of energy in data-centers ,making use of machine learning regression based algorithms for prediction and then carry out virtual migrations techniques to make maximum utilization.. By doing so we hope to deliver significant power savings, a powerful energy analytic, real-time power consumption monitoring and in turn make sure the power savings and CO2 emissions are measured and quantified accurately. This conforms that deliberate access and techniques could be powerful in addressing climate and energy powerful thereby limiting the enervation.

Keywords : Virtual Machine , Power Management,VM Migration ,SVMs

I. INTRODUCTION

Energy and power consumption is a crucial challenge that is faced by mankind. In order to reduce the impact of climate change, maintenance of power or energy efficiency is extremely essential. It consists of choosing appropriate set of sources to produce energy by minimizing losses and costs. At present data-centers and Information and Communication(DIC) sector produce a severe 2% of global CO2 emissions due to advancement in technologies in cloud computing and growth of internet services. Use of mobile devices, online gaming and live video streaming contribute to 60% of the traffic and it might rise up to 80% by 2020(predicted).

Data-centers are nothing but computer warehouses which contain huge data to manage day-to-day transactions. They run 24/7 and to ensure their efficiency, servers are installed to use and store large amounts of data. This leads to heavy consumption of energy because it needs cooling equipment, lighting and power requirements. The cooling systems account to 40% of the energy consumed followed by water chillers, which provides chilled water to the cooling coil to remove the heat emitted by the servers.

To ensure optimization of power, renewable resources need to be fully utilized since it is available freely, hence minimizing the
use of conventional generation plants which is bought from the grid. Due to the increasing consumption of energy leading to an alarming increase in climate change and CO2 emissions, various policies and measures have been present in the conventional or existing power systems.

Intelligent system is equipped with sensors throughout the system, it elf-monitors and self-heals whereas the existing power system consists of only a few sensors, does not monitor itself and needs manual restoration.
Intelligent power system performs remote check/test, uses pervasive control and gives customers a lot of choices as opposed to the existing system which performs manual check/test, exhibit limited control and gives customers only a few choices.

This system makes use of a melange of different parameters such as CPU usage (60%), Memory usage (30%), Disk-IO (5%) and network_IO (5%) and combines it into one single parameter called total CPU utilization to give an overall output of the power consumed.

II. OBJECTIVES

Intelligent energy system has to ensure to:

1. Integrate large amounts of renewable energy resources in the place of existing use of non-renewable energy resources.
2. Make sure that energy demanded by the customer is satisfied without compromising the safety of the system and its supplies

Using cloud computing techniques several Virtual Machines can be consolidated into one single Physical Machine. These support various virtualization technologies like XEN, KVM etc... The source host has a state of guest OS which can be replicated on the destination host. This requires the state of the processor, memory, local storage and the network. This is called live migration where the VM can only stop for a very small duration.

III. ANALYSIS OF RELATED WORK

Various works have been done on maximum power utilization of data centers by different authors. Some of them are mentioned in the following section.

It has been introduced in [1] that the concept of EMS (Energy Management Systems) which is basically combined with power networks to efficiently manage power resources. It supervises, controls, optimizes generation and transmission systems. It allows the utilities to analyze and store data from thousands of points, performs network modelling, and finds power consumed and methods to reduce the same. EMS is executed for both utilities and the end customer to analyze the usage of electricity and to gain savings in electricity. The monitor and control functions are known as SCADA, Supervisory Control and Data Acquisition. NEMS can also be defined as the system designed to perform control of electro-mechanical facilities in most buildings leading to large consumption of energy like heating, lighting facilities, etc. These EMS also used to distribute functionalist to water, gas and electricity supplies. In this paper the methodology used is a SCADA(supervisory control and data acquisition) architecture consists of the following components:- GIS/CIS, Operation support, Historical archival system, Distribution network analysis, billing, RTUs, relay and meters, and functions like-n/w topology, optimal switching, short circuit analysis.

This paper [2] emphasizes on the need to bring about the efficiency of energy in data centers and provides several methods for bringing about GREEN operation to those data-centers. Since energy consumption by data-centers was growing at an alarming rate due to its availability twenty four seven and its cooling system, there was an increased need to maintain the power consumption. Hence these components need to be preserved at normal temperatures to make sure of achieving reliability on data centers, longevity and maximum return on the investments.

Alternatively paper presented [3] a system based on Multi-user Agents (MAS) which self regulates a set of power sources organized as a micro-grid in order to achieve optimal solution. The micro grid was made autonomous which could interact with other agents and take necessary steps to optimize power. The system is composed of different type of energy producers, called sources, and energy consumers, called loads. If the produced energy is not sufficient to supply the energy demanded by the loads, then extra energy contained in the grid has to be supplied. Optimal solution for the energy management problem is obtained when a state satisfied all the goals and constraints. MAS was chosen to design this system where the characteristic of the sources are taken and integrated with other agents to make the solution global and available to other agents as well. This optimal problem consists of

maximum utilization of renewable resources and a combined group of sources and loads. The components of micro-grid consists of three parameters:

1. **Loads**: Power demanded by the load, whether it is reversible or not and what type of energy resources are used.
2. **Sources**: Power, capacity, condition of the power, its efficiency, and total cost incurred.
3. **Storage systems**: Charging power, discharging power, capacity, and efficiency of the system.

The paper [4] talks about Smart grids, which were implemented for smart sensing and effective control of power consumption. It proved that smart grid technology could be a beneficial technology for power system stability, customer's satisfaction, load distribution and all types of grid operations. The smart grid concept is to provide grid observation, create controlling of assets, and enhance security and performance with cost-effective operations, maintenance and system planning. Through smart grid technology, the new grid is expected to provide self-corrective, reconfiguration and restoration capabilities. It provides a two-way communications and pervasive computing capabilities to improve reliability, control, safety and efficiency of power consumption. The objectives of the smart grid were to provide all options of storage and generation of power and ensuring that it is cost-effective and efficient in operation. However the major disadvantage being Security because the smart grid systems are controlled through the digital communications network, where important and private data are stored. So a proper mechanism should be implemented to ensure security and privacy in systems. The security and cyber securities are major challenges of recent smart grids systems. And smart grids have been implemented in developed countries whereas in less developed countries it is lagging behind.

This being the base paper [5] is aimed at analyzing, evaluating and presenting the current advances in consumption of energy and efficiency in data-centers in the European Union. It makes use of the data submitted by various companies to minimize the energy consumption. It implements measures to bring about the efficiency of data-centers component to maintain and eco-friendly and a green design. This is the analysis that is identified as Power Usage Effectiveness (PUE) of the deftness following necessary policies to reduce consumption is declining year after /year reaching a prime value of 1.64. This affirmation that if the organization implemented these conceptualizations, then it could bring about reducing change in climate issues and efficient usage of power and electricity.

The paper [6] is a discussion about challenges and issues in reducing energy demand. This gives a clear idea of deterioration and power consumption problem. The ideas from natural science, economics, psychology, innovation studies and sociology are integrated in order to provide different solutions to this problem. It describes the link that exists between energy demand and the scale of physical and human systems. It also emphasizes on energy consumption and economic growth. Large energy flow is required by the complex systems.

The paper [7] describes the latest trends in data centre energy consumption. The efficiency of data centers has to be improved. An evolutionary prototype for the mentioned requirement is done in this paper. This helped the companies to address their personalized energy efficiency needs. An interactive system was built which supported the calculation, evaluation and presentation of the data center energy efficiency. It help in conducting efficiency development of data centers. A prototype was implemented which was found to be flexible where in new features to increase the efficiency could also be added. It could record the values that are measured and the other data in order to perform calculations of data center efficiency.

IV. PROPOSED METHODOLOGY

The methodology of the proposed idea is two folds, first it is divided into a pre-processing module where we have generated real time data-sets simulating the values of a real data center and taken into account a number of parameters such as CPU utilization, Memory usage, Network IO, Disk IO, total consumption in GFLOPS . The second is a Support Vector Algorithm algorithm and the Virtual Machine Migration technique.

Datasets: The dataset that was used in this paper was generated through a simulator which mimicked an actual data center using various randomised function and probability distribution techniques such as Poisson's distribution, Bernoulli's distribution and Gaussian's distribution.

There are certain existing time series methods and popular approaches that use normal time series techniques for forecasting. However, the same , when applied to unique patterns applications proves to be in feasible .SVMs [3] make use of an insensitive linear function to solve the regression problems where the data are mapped onto a high dimensional feature space with a nonlinear mapping 'Φ'. The Support Vector Regression algorithm uses 'Φ' known as the transformation function to predict the original data points from the initial Input Space, to a generally higher-dimensional Feature Space (F). The aim of using the insensitive loss function ξ is to determine a function that fits current training data with a deviation equal to or less to ξ , and at the same time is as flat as possible. This in simple words means that one seeks for a small weight vector by minimizing the standard **w** as shown in (1). SVR has an excellent performance regarding the perfection of solving non-linear regression and is able to minimize structural risk to find the function **f** and hence solves the problem of over-fitting effectively and has good generality capability.

$$\min \frac{1}{2}\left\|w^2\right\| + c\sum_{i-1}^{n}(\xi_i + \xi_i^*) \qquad (1)$$

We consider an N-dimensional space. SVM finds a hyper-plane that classifies the data points distinctly. Many hyper-planes could be chosen to separate these two classes of data points. The data points that are closer to the hyper-planes are called Support Vectors. By using this algorithm we are able to predict and forecast the threshold value based on which the entire migration takes place, in turn optimizing the entire Data-Center.

Virtualization [15] basically acquaints a level of indirection with a framework to decouple applications from the fundamental host framework. And since migrating Virtual machines is not dependant on just the availability but also on the architecture of each server as they vary from one another .Once the threshold value is obtained from the SVR algorithm . Next is to considered is to select the virtual machine available for migration. The system resources are usually limited. Hence the available VM chosen for migration will have an impact on the entire data center. There are certain strategies for choosing VM for migration:

1. **Minimum Memory Quota Choice Migration**: The memory value of the application before VM is referred to as Memory Quota. We select the one with minimum memory quota as VM ready for migration.

2. **Random Migration:** The VM is selected at random from a list of VMs waiting. This has the advantage of equity in selection and faster selection. It also increases the number of VM migration. But the only disadvantage being unsure if the VM is suitable for migration.

3. **Dynamic Prediction Migration**: This is the methodology proposed in this paper which is based on dynamic

consumption of VM memory. This algorithm is used to decide the VM with a combination of CPU usage (60%) , Memory Usage (30%), Disk-IO (5%) and network-IO (5%) suitable for migration.

Total Power Consumption = { (0.6 x CPU)+(0.3 x Memory)+(0.05 x Network)+(0.05 x Disk) }

After selecting the VM for migration, a host target must be selected. It has the following categories:

1. Minimum load priority- where VM runs on the host.
2. Load balance- for increasing performance.
3. Optimum based on prediction- where target host is considered for VM deployment which can be chosen using VM_DM algorithm as in [14].

The V Migration algorithm is as shown below:

1.**while** *runtime* - - > 0 **do**
2. **for each** Server Utilization **do**
3. **for each** calculate the *under* and *over-utilized server* **do**
4. Convert into ***Giga-Flops***
5. **if** *under-utilized serve*r < available
6. **if** startMigration **then**
7. remove (temp VM);
8. **end if**
9. **end if**

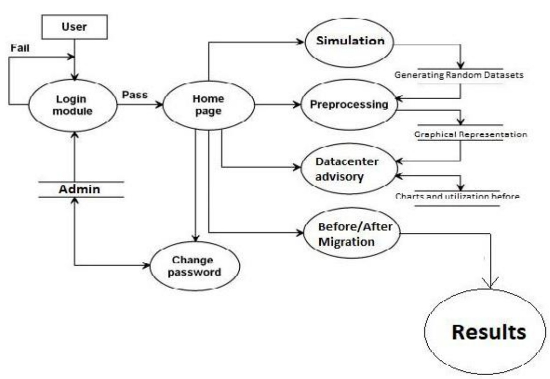

Figure.1 *The data flow diagram of Power Management system in Data-centers is as shown defines how the system works after user login and various pages controlled by the user and the admin, that we designed for the study done during the execution of the project.*

Energy efficiency of data center energy is how less we utilize the energy for hardware or software equipment for a given service in data centers. Hardware equipment can be IT equipment (e.g. network and servers) or supporting equipment (e.g. power supply, cooling and data center building itself). The entire data center and end-users' applications managed by Cloud Management Systems (CMSs) comes under software equipment. Hardware equipment takes a larger share of power consumption of data centers, and hence, energy consumption should be reduced by managing PMs and VMs efficiently in Cloud Data Centre (CDC).

There are two general types of VM consolidation:

Static

Dynamic

In static consolidation, after the arrival of a job, placement and sizing of VMs on PMs are determined in prior and this placement is consistent for a certain period of time. When jobs are short running with VMs having predefined PMs resources, it is suitable to use this VM consolidation. Simple heuristics or historical VMs demand patterns cause energy reduction in this case. But there can be a deficiency in available resources during high utilization periods in this case. Dynamic VM consolidation is the one where PMs can be less utilized when VMs undergo live migration or re-allocation among PMs where the services are not interrupted. The performance is based on QoS which takes place between the tenant and the service provider. The unused power is saved by turning them off and hence the power efficiency is increased in data centers. Hence it is efficient in utilizing resources and reducing the wastage of energy.

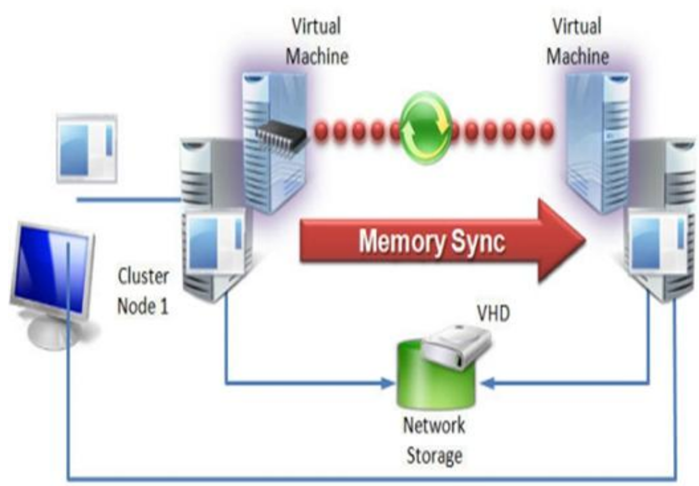

Figure.2 represents theVM live migration obtained by shared-nothing-vm-live-migration-windows-server-2012-hyper-v used for our analysis.

V. RESULTS AND DISCUSSIONS

The analysis of this method has led to a new form of power management system which is completely different from diverse other technologies such as [8], [9], [10], [11], [12] and [13] leading to a new form of green computing. The support Vector regression algorithm is able to forecast significantly well in assigning the under-utilized virtual machines of a host to the available virtual machines by migrating it to make maximum use. This is a new form of green computing and seen to produce consistent up to 9.5% energy savings along with a real time power consumption monitoring without affecting the server performance.

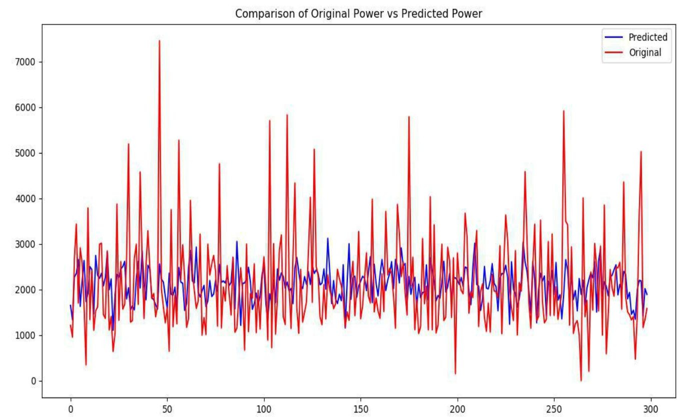

Figure 3 *represents the graph of Cross validation of the Original power consumption vs the predicted power consumption using SVMs, graph obtained when the system was run during the execution of our idea.*

One of the best practice to optimize power consumption is by periodical assessment using software designs to identify the servers demanding high energy. Implementing cold aisle containment systems in existing systems is the fastest and easiest way to cool the servers in low budget.

Optimization of power occurs when the supply of power to the servers is based on the priority through which the less useful servers use limited amount of energy. Using sustainable power management increases energy efficiency and also reduces the CO2 emissions.

There is an increase in grid efficiency which results in downward pressure on electricity prices by eliminating large capital investments. It requires a lot of man power to create a smart grid alone hence creating new job opportunities and parallel economic growth. The power supply industry favors fast and robust technologies in delivering power to complex systems supported by computer control. This results in profitable optimization of power in high performance computations.

VI. SIGNIFICANCE OF THE STUDY

By using the concepts of reinforced learning and supervised learning such as Powerful Energy Analytics for data centers, delivers consistent energy savings. It helps reduce cost, manage capacity and increase environmental responsbility. The demand for power in data centers has been increasing rapidly. It also gives a solid understanding of data center energy consumption.

VII. CONCLUSION

In a world with 509.147 data-centers, power management is a vital task. Under-utilization of servers, not only affects the monetary value of the establishment/firm, but also increases the carbon dioxide levels in the atmosphere, thereby contributing to the degradation of the environment. In this research we built and optimized a SVM model for accurate forecasting for both short term (few days) and medium term (few weeks). The validation of the results have proved and showed significant results. Our future works will be to carry out empirical studies to identify top techniques for each class of prediction.

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