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Energy Management Models for Efficient Cloud Environment: A Review

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Abstract: Cloud Computing is an evolving area of efficient utilization of computing resources. Data centres accommodating Cloud applications ingest massive quantities of energy, contributing to high functioning expenditures and carbon footprints to the atmosphere. Hence, Green Cloud computing resolutions are required not only to save energy for the environment but also to decrease operating charges. In this paper, we discussed the balance between server energy consumption, network energy consumption, and end-user energy consumption, to present a fuller assessment of the benefits of cloud computing. The issue of energy consumption in information technology equipment has been receiving increasing attention in recent years and there is growing recognition of the need to manage energy consumption across the entire information and communications technology (ICT) sector. Various architectures have been discussed for energy efficiency. The central objective of this paper is to initiate research and development of energy-management models and strategies for data centres in such a way that brings Cloud computing as a maintainable ecological conventional technology for achieving cost-effective, organized, and technical enhancement for future generations.

Keywords: Cloud Computing, ICT, Energy consumption, Green Cloud Computing.

I. INTRODUCTION

In last few decades networks of high speed have grown a lot, which has led a alarming increase in its usage involving thousands of transactions of e-commerce and lots of web queries in a dad**.** Data centres are used to handle demand which is ever-increasing; it joins thousands and hundreds of servers to other infrastructure like storage, cooling, network systems [1]. A lot of internet companies like Amazon, Google, yahoo and eBay are operating data centres worldwide.

These developments commercialization is currently defined as cloud computing [2], where deliverance of computing is done on the basis of pay as you go. Traditionally a lot of money and time was invested in maintenance and acquisition of these computational services**.** Rise of cloud computing is quickly changing approach from ownership based to subscription oriented by giving access to on demand services and scalable infrastructure. Users can access, share and store information of any type in cloud. That is, small or medium enterprises/organizations do not have to worry about purchasing, configuring, administering, and maintaining their own computing infrastructure. They can focus on sharpening their core competencies by exploiting a number of Cloud computing benefits such as on-demand computing resources, faster and cheaper software development capabilities at low cost. Moreover, Cloud computing also offers enormous amount of compute power to organizations which require processing of tremendous amount of data generated almost every day. For instance, financial companies have to maintain every day the dynamic information about their hundreds of clients, and genomics research has to manage huge volumes of gene sequencing data.

Cloud computing architectures can be either public or private [3], [4]. A private cloud is hosted within an enterprise, behind its firewall, and intended only to be used by that enterprise [3]. In such cases, the enterprise invests in and manages its own cloud infrastructure, but gains benefits from pooling a smaller number of centrally maintained high-performance computing and storage resources instead of deploying large numbers of lower performance systems. Further benefits flow from the centralized maintenance of software packages, data backups, and balancing the volume of user demands across multiple servers or multiple data centre sites. In contrast, a public cloud is hosted on the Internet and designed to be used by any user with an Internet connection to provide a similar range of capabilities and services [3]. A number of organizations are already hosting and/or offering cloud computing services. Examples include Google Docs [5], Amazon's Elastic Compute Cloud and Simple Storage services [6], Microsoft's Windows Azure Platform [7], IBM's Smart Business Services [8], Salesforce.com [9], and WebEx [10].

But while its financial benefits have been widely discussed, the shift in energy usage in a cloud computing model has received little attention. Through the use of large shared servers and storage units, cloud computing can offer energy savings in the provision of computing and storage services, particularly if the end user migrates toward the use of a computer or a terminal of lower capability and lower energy consumption. At the same time, cloud computing leads to increases in network traffic and the associated network energy consumption. In this paper, we explore the balance between server energy consumption, network energy consumption, and end-user energy consumption, to present a fuller assessment of the benefits of cloud computing. The issue of energy consumption in information technology equipment has been receiving increasing attention in recent years and there is growing recognition of the need to manage energy consumption across the entire information and communications technology (ICT) sector [11]–[13]. It is estimated that data centres accounted for approximately 1.2% of total United States electricity consumption in 2005 [13]. The transmission and switching networks in the Internet account for another 0.4% of total electricity consumption in broadband-enabled countries [14]. In addition to the obvious need to reduce the greenhouse impact of the ICT sector [12]–[15], this need to reduce energy consumption is also driven by the engineering challenges and cost of managing the power consumption of large data centres and associated cooling [16], [17]. Against this, cloud computing will involve increasing size and capacity of data centres and of networks, but if properly managed, cloud computing can potentially lead to overall energy savings. The management of power consumption in data centres has led to a number of substantial improvements in energy efficiency [18], [19]. Cloud computing infrastructure is housed in data centres and has benefited significantly from these advances. Techniques such as, for example, sleep scheduling and virtualization of computing resources in cloud computing data centres improve the energy efficiency of cloud computing [17].

II. ENERGY CONSUMPTION IN CLOUD COMPUTING

Clouds have various elements using enormous energy. Mainly when user accessing Cloud data using different services such as SaaS, PaaS, or IaaS over Internet, user send information through an Internet service provider's router, connecting with gateway router within a Cloud data centre. In data centres and at user side data goes through a local area network and are processed on virtual machines, hosting Cloud services. Each of these computing and network devices that are directly accessed and indirect devices such as cooling and electrical devices, are the major contributors to the power consumption of a Cloud. Thus thermal and energy management are the major issues of cloud computing system due to aggregation of computing, networking, and storage hardware, the energy consumption required to transport the data from and to the user constitute. resulting from increased component density and excess power consumption ,large amount of heat and demand for excessive electricity point out areas of concern in cloud computing – system reliability and operational costs[20,21,22]

Environment being a sensitive topic. Researchers are trying to decrease energy use and produce models of energy aware to optimize total energy, involving costs of operation, in cloud environment. Li et al [23] gave a cost model for taking out total cost of utilization and ownership in cloud environment. For calculation suits of matrix were also developed. But howsoever their calculation granularity was a single hardware component. Likewise Jung et al [24] focused on power which was consumed by physical hosts. Their models of energy consumption do not take account into the impact of specific workloads working on specific hardware**.** Schikuta and mach [25] proposed cloud cost model which consumer provider based. JVM java virtual machine is used for their calculation of energy consumption. Because JVM life cycle is dynamic it is difficult to calculate actual number of JVM. Their calculation of energy consumption depends on number of JVM instances on every server. zomaya and lee put forth a energy model of cloud tasks for reducing energy consumption. However the model only assumes relationship between energy consumption and CPU utilization is along with linear increasing. Chen et al [26] gave a linear power model which shows the power consumption and behaviour from individual components to a single work node. Power meter foe VMs is joule meter [27]. This allows the software components to keep a check the resource utilization of VMs and then change it to energy used depending on power model of each and every hardware resource. Some works mentioned above have made few efforts in benchmarking system and energy performance. Though none have identified all association among energy consumption and dynamic as well as static tasks with configurations that are different in system performance as well as cloud environment.

III. GREEN CLOUD COMPUTING

Cloud computing contributes for speed up Green IT which is justified by Forrester Research. Cloud based services ranging from servers, storage solutions, business applications, Software-as-a-service and Infrastructure-as-a-service – will all contribute to leveraged IT management leading to decreased e-waste illustrating a direct correlation between cloud computing and going green. A Microsoft Study encapsulated in a whitepaper provides further evidence that cloud computing helps companies move in the direction of going green. [28] The study showcases how small businesses benefit from cloud computing. Jonathan Koomey – an efficiency expert – claims that cloud computing vendors use power, infrastructure and assets much more efficiently. Cloud computing and its obvious advantages are hard to ignore: decreased costs, enhanced efficiencies, optimized data centre management, better application performance, environmental friendliness, increased capacities and flexible provisioning. Cloud computing is certainly the right solution for businesses not only to help them move toward going green but also to benefit from the host of other advantages cloud computing offers. This save fossil fuels, save on energy, save paper, minimize landfill waste, reduce e-waste, and much more. [29] Ander-son et al [30] define (FAWN) which is fast array of wimpy nodes as novel for cloud architecture for low power data intensive computing. On large scale for good data access FAWN combines CPUs of low power with local flash storage of small amount and I/O capabilities. FAWN has evaluated on many workloads. The finding suggests that compared to conventional CPUs of high performance, nodes of lower frequency are much better. FAWN architecture appears to be incompatible in solving problems which could not be parallelized or working set size could not be to be allotted into smaller nodes available memory. In Gordon architecture, Caulfield et al define which is example of data centric system-low power. By using flash memory, data centric programming system and processors of low power, Gordon improves performance and decrease power consumption for data centric applications. Results of the experiments presented are able to out-perform disk-based by 1.5 to 2.5 times more performance.

IV. EXISTED ENERGY MANAGEMENT ARCHITECTURES

Broadly two types of energy management models of energy management are static and Dynamic Architectures for energy management

4.1 Static architecture

Optimization in computational clouds is to create the cloud systems by using low-power components and keeping the system at the acceptable level of performance. Options of low power handheld technology and mobile, can be used in cloud systems CPUs may use 35%-50% of total power of cloud node [31] it make it most energy consuming components. Memory module [32] is other expensive energy components. CPU and low power memory components can support effectively energy aware management (static power). HPC machines popular examples are IBM blue gene/L [34] and green density [33] these are made of modules of low power.

4.2 Dynamic architecture

Dynamic architecture technique involves all methods which helps cloud systems run –time adaptation according to requirements of current resource and cloud system states [35] dynamic characteristics. Dynamic architecture technique divides power aware cloud on the basis of two components: a. Processors b. Memory.

- **Power-scalable memory**

Tolentino ET AL IN [20] developed (memory MISER) in cloud systems is a good answer for power scalable memory management. It uses a Linux kernel and PID controller's daemon implementation to off line and on line memory scaling in system operating mode. It was tested on 32 GB of SDRAM per processor and 8 processors on sequential and parallel applications. The results presented in [32] that it might reach 70% decrease in memory energy consumption and 30% decrease in overall system energy consumption with a decrease in performance of less than 1%. In cloud systems memory MISER promises energy efficiency.

- **Power-scalable processors**

In the modern day technologies scalable power processors are available for cloud systems. The power of these power processors can be minimised by using the following types of the scaling modules:-

(i) Dynamic Frequency scaling module
(ii) Dynamic voltage scaling module
(iii) Dynamic voltage and frequency scaling module (DVFS)

The Processor Power can be calculated by adding the Dynamic power used and the static power wasted due to various leakages i.e. Pt = Pd + Ps where Pt is the Total Power, Pd is the Dynamic Power used, and Ps is the static power. The dynamic Power consumption is dependent on the clock frequency; the number of active gates in the CMOS based processor, voltage used and the total capacitative load. The static power is the leakage of energy in the system even when the Processor is idle. It is observed from the experiments that the peak performance of the traditional clouds for scientific applications can be up to 5-15 % of the Peak Performance. The performance and the energy saving are inter related and are user defined. The priority can be set by a weighting factor for either energy saving or the performance. The experiments have shown that the energy saving can be achieved up to 30 % with less than 5% reduction in performance. With the Cloud planners having knowledge of the application the Off-line scheduling can be made effective.

- **Load balancing**

The distribution of the workload in the computing cloud is carried out to ensure optimum utilisation of resource with minimum response time and avoiding overload on the system. To achieve this some of the nodes in the system can be either switched off or can be placed at minimal power. Load Balancing is hence a trade of between usage of power supply and the system performance. This load balancing system was developed as dynamical cloud operational mode controller and was used in two types of cloud base systems i.e. network server and an operating system for clouded cycle servers. This technique has limited applications.

V. CONCLUSION

In this paper various energy management architecture are discussed. Different architectures are saving energy according to their various constraints that are making them energy efficient algorithms. In this paper, an important technique discussed is Load balancing. The main aim of load balancing & task scheduling methodology is to distribute the workload across the computing cloud to achieve optimal resource utilization, minimize the response time, and avoid overload of the system. As the result some nodes in the system can be switched to the stand-by mode or just switched off. Although the energy can be saved at low power mode or inactive nodes, the overall system performance can be adversely impacted, which may be a reason of increasing the system energy utilization. These energy savings varies during the different loads and scenarios. As we are introducing Cloud Computing in every field, these energy savings will helps in decreasing the power bills and making environment eco friendly that is very much valuable in present time.

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