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ENERGY CONSUMPTIONS IN CLOUD DATACENTERS – A REVIEW

Sunidhi Baghel[*1] & Dr. M. A. Rizvi[2]
[*1]M.tech Scholar Computer engineering and applications NITTTR, Bhopal
[2]Associate Professor and Head Computer engineering and applications NITTTR, Bhopal

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ABSTRACT
The growing demand of computation, large data storage required for running a high performance computing enterprise and high dimensional data primarily based web application increases the energy and power consumed by massive infrastructure. Cloud computing is providing a solution as part of the green IT initiative to reduce the adverse environmental impacts and save energy. In this article, we review the "green" strategies, which are applied in data centre to reduce energy consumption. This paper presents a review of various energy-efficient scheduling methods based on existing DVFS techniques in a cloud environment .The best power-saving percentage level can be achieved by using both DVFS and DNS.

Keywords: Cloud computing, Green Computing, Datacenters, Energy Efficiency, Dynamic voltage frequency scaling (DVFS), Dynamic Shutdown Scheme (DNS).

I. INRTODUCTION
Data centers are cost-effective infrastructures for storing large volumes of data and hosting large-scale service applications. Data centers contain hundreds of thousands of servers, interconnected via switches, routers and high-speed links. Today, large companies such as Amazon, Google, Face book, and Yahoo! routinely use data centers for storage, web search, and large-scale computations [1].With the rise of cloud computing, service hosting in data centers has become a multi-billion dollar business that plays an important role in the future information Technology trade.

However, a large-scale computing infrastructure consumes huge amounts of electrical power leading to terribly high operational costs which will exceed the cost of the infrastructure in a very few years. In 2013, U.S. data centers consumed an estimated 91 billion kilowatt-hours of electricity, equivalent to the annual output of 34 large (500-megawatt) coal-fired power plants. The annual electricity consumption of data centers is projected to increase to roughly 140 billion kilowatt-hours by 2020, the equivalent annual output of 50 power plants, costing American businesses $13 billion annually in electricity bills and emitting nearly 100 million metric tons of carbon pollution per year [2].

In a datacenter, power consumption is mainly due to servers, networking devices, and cooling systems. There are two main approaches for reducing the energy consumption of datacenters: (a) shutting down devices or (b) scaling down performance. The former, commonly referred as Dynamic Power Management (DPM), results in the greatest savings, since the average workload often remains below 30% of its capacity in cloud computing systems[3].

Dynamic Voltage and Frequency Scaling (DVFS), a voltage reduction technique for battery-operated systems scaling, was introduced in the 90s [4], which dramatically reduces power consumption in large digital systems by adapting both voltage and frequency of the system with reference to dynamic workloads. Equipped with DVFS, a regulated system can adjust the supply voltage of a digital circuit at the functional boundary for the speed requirements, the temperature, and the technology parameters.

DVFS describes the two power saving techniques (dynamic frequency scaling and dynamic voltage scaling) used to save power in embedded systems including cell phones [4] The servers left idle are put into sleep mode

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(DNS scheme) Dynamic Shutdown Scheme. According to Open Compute project report [5], 93% of the energy consumption in a data centre depends upon efficient utilization of computing resources at data centers.
The rest of this paper is organized as follows: in Section 2 a brief introduction of Cloud computing, basic principles and concepts of Green computing are discussed. Section 3 presents related work regarding Energy Consumptions in Cloud Datacenters; Section 4 described the conclusion of the paper.

II. BACKGROUND

2.1 Cloud Computing

Cloud computing are another form of distributed and parallel computing and a superset of Grid computing. It's well-known to be an evolving paradigm of equal resource sharing among the nodes. It's a recently developed technology based on pay-per-use model. It provides a use of energy-efficient, price effective technologies that helps throughout accessing, sharing of services and storage and management of resources [13] [14]. The benefits of cloud computing is access of network, infrastructure sharing, saving of cost, maintainability, reliability, flexibility, location autonomy and wide-variety of services etc. [15]

A. Services of Cloud Computing

Cloud is referred to a pool of data centers on that various Services are deployed through web. Such services are generally classified in three categories: SaaS (Software as a Service), IaaS (Infrastructure as a Service) and PaaS (Platform as a Service) [16] [17] as depicted in Fig. 1 [13] [18]. In, SaaS service model the consumers acquire the potential for accessing of application or service that's deployed on the cloud like Salesforce.com. In PaaS, consumers acquire the potential for accessing platforms so that they will deploy their applications and softwares within the cloud. whereas in IaaS consumers acquire the potential for controlling and managing the systems in provisions of storage, connectivity of network, applications and operating systems, however can't controlled their selves the infrastructure of cloud. the other service like CaaS (Communications as a Service) is understood to be a set of SaaS that is particularly associated with market or business and used to depict hosted services of IP telephony [19].

B. Deployment Models of Cloud Computing

The deployment of cloud computing is varied based on the requirements and based on these requirements the deployment models can be categorized into four types such as Private Cloud, Public cloud, Community cloud and Hybrid cloud [19] [20] .These models are described as follows:

- i) Private Cloud: It is deployed, controlled and maintained for a particular organization or a company.
- ii) Public Cloud: It is available for commercial basis which allows the users to build up and deploy a service the environment of cloud.
- iii) Community Cloud: It is utilized by number of organizations which are having common needs and interests.
- iv) Hybrid Cloud: It exhibits a number of clouds with different types but having the potentiality through their interfaces to allow and move applications or data between one to another cloud. It can be see a combination of two or more clouds.

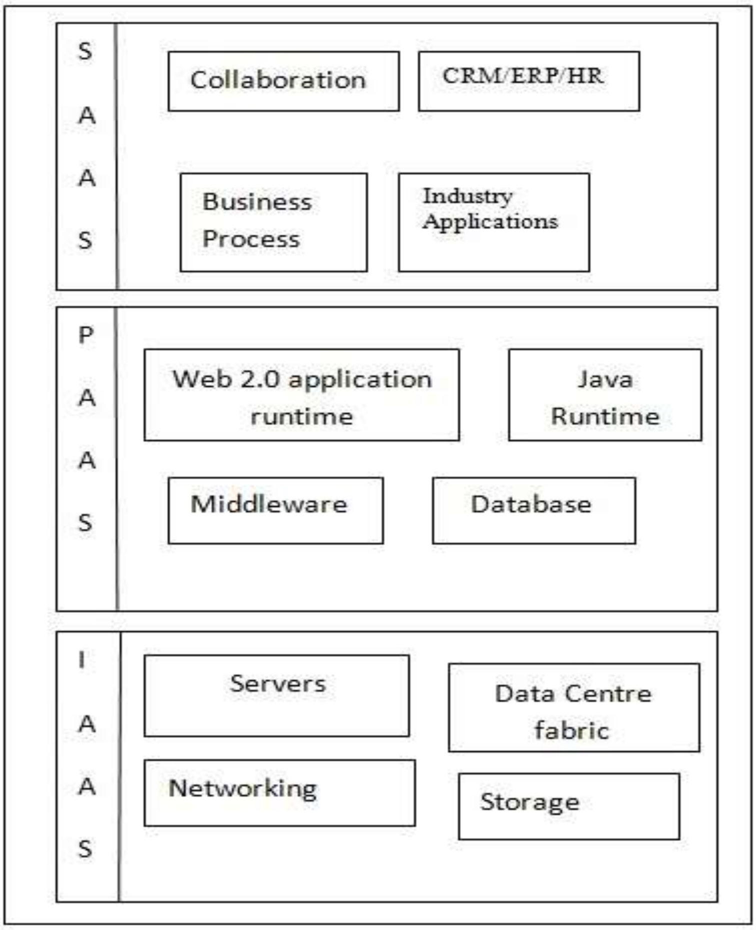

Figure 1 Services of Cloud Computing

2.2 Green computing

This section gives a brief discussion on origin, definitions, Green IT and need of Green IT as follows:

A. Origin

The origin of Green Computing is started in 1987, when the report named "Our Common Future is issued by the World Commission. It basically stated the idea about "sustainable development [21] [22]. In 1992, one consumer Energy Star plan is launched by the U.S. Environmental Protection Agency (EPA) [23]. The purpose of this is to minimize the consumption of energy it was primarily for computer products.

B. Definitions

Green Computing refers to the efficient use of computers and other technologies with respect to environment so that the primary goals such as energy efficient peripherals, improve the consumption of resources and electronic waste can be satisfied. These goals will not only make the resources more efficient but also enhance the overall performance.

In the technical way, the Green Computing can have 2 aspects:

(i) For software technology the purpose is to create such methods that can enhance the efficiency of program, storage and energy. While (ii) In hardware aspect there is need of such technologies which can not only minimize the consumption of energy but also make it economically efficient with the help of recycling [24] [25]

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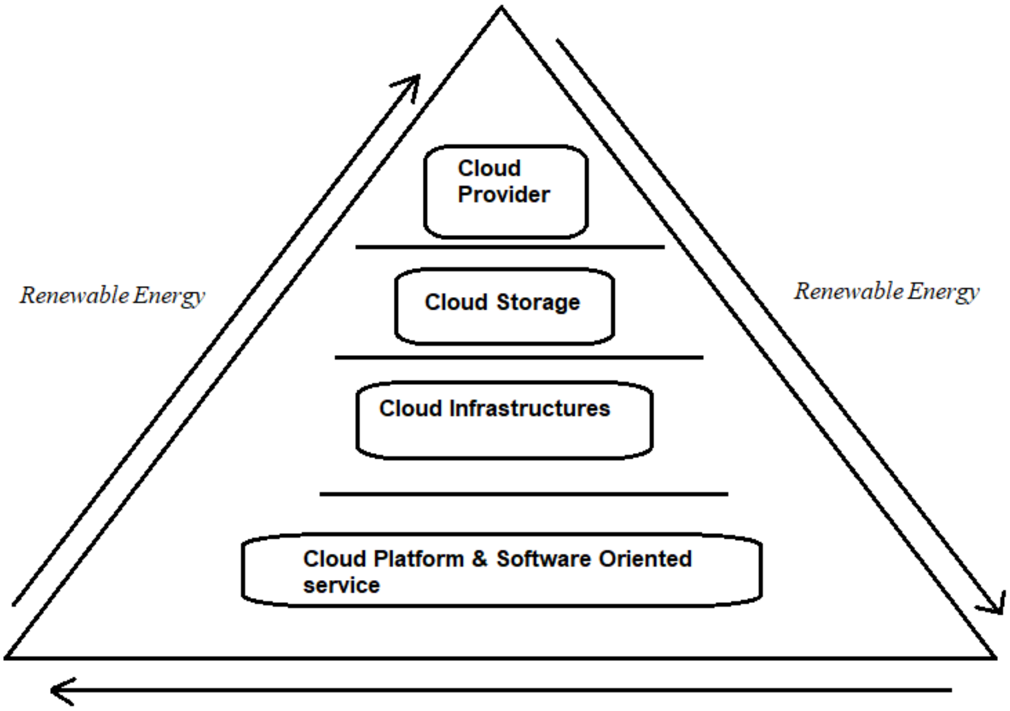

Figure2 Green Cloud Computing

C. Green IT

Green IT, is a development and proposal of new computing models that used to make the IT resources more energy efficient both in terms of cost and power. While using the IT resources there are number of key areas that should be taken care. The Primary key areas of Green IT are discussed further.

D. Need of green IT for Cloud Computing

In nowadays, where the data centers and servers are remotely controlled under the Cloud Computing models there is a need of green computing to make these more energy efficient and economically reliable. Whereas providing the Cloud services, the service provides should be ensured that they can provide energy efficient services with economical cost. But the challenging and complex task is to lower the usage of energy of data centers. As data are growing exponentially, the Green Cloud computing having problems related to infrastructures for computations that may not only minimize the consumption of energy but can also build the Cloud services reliable and economically efficient.

III. RELATED WORK

The dynamic voltage and frequency scaling (DVFS) technique is commonly used to reduce the power consumption of electrical devices such as cell phones, PDAs, and PCs. The power consumption of an integrated circuit is proportional to the easy formula fcv2, with f the frequency, c the capacitance, and v the voltage. Thus, the supply voltage and work frequency deeply have an effect on the energy consumption of integrated circuits. The DVFS allows integrated circuits to run at different combinations of frequencies and voltages. Voltage supply will be increased or decreased relying upon circumstances. The DVFS can dynamically lower down the supply voltage and work frequency to reduce the energy consumption while the performance will satisfy the requirement of a job.

Energy management techniques in cloud environments have also been investigated within the past few years. In [6] described how servers can be turned ON/OFF using Dynamic Voltage/Frequency Scaling (DVFS) approach to adjust servers' power statues. DVFS adjust CPU energy consumption according to the workload.
However, the scope is limited to the CPUs. Therefore, there's a requirement to look into the behavior of individual VMs. These can be possible by monitoring the energy profile of individual system components such as CPU, Memory (at run time), disk and cache.

According to Accenture Report [7] presented by Garg et al. [8]. There are following four key factors of green Cloud computing: the first factor is Dynamic provisioning. In dynamic provisioning, Cloud suppliers monitor and predict the demand and allocate the resources according to demand. Thus, datacenters always maintain the active servers according to current demand, which results in low energy consumption. Second factor is Multi-tenancy. Using multitenancy approach, the same server allows the flattening of the overall peak demand which might minimize the need for extra infrastructure and results in greater energy savings. Third factor is Server Utilization. In general, on-premise operations run at 5 to 10 % of average utilization whereas cloud may attain 40 to 70 % utilization. And the last factor is Datacenter efficiency. Power usage effectiveness is used to measure the efficiency of data center power. Higher PUE is achieved by using high speed network, virtualized services and reduce power loss through improved cooling rate.

Sarji et al. [9] proposed 2 energy models for switching between the server's operational modes. They analyze the actual power measurement taken at the server's AC input, to determine the energy consumed in the idle state, the sleep state and also the off state, to effect switching between this states. However, switching between power modes takes time and may translate to degraded performance if load goes up unexpectedly. Moreover, the set of servers that serve the load can also vary frequently (a results of load balancing), leading to short idle times for many servers.

In [10], 3 power saving modes DVFS, DNS, and DVFS + DNS were compared. The servers left idle are put into sleep mode (DNS scheme) whereas the supply voltage of the under loaded servers is reduced (DVFS scheme). The combination of DVFS and DNS schemes has the most effective energy savings and can reduce the initial energy spending down to almost a third.

In this paper**,** [11] Proposed a green energy-efficient method of scheduling using the Dynamic Voltage Frequency Scaling (DVFS) technique. DVFS reduces the power consumption of infrastructure. Minimizing the number of computing servers and time reduces energy usage and improves resource utilization. The servers are run at different combinations of frequencies and voltages. This method efficiently schedules the tasks to resources without compromising the performance of the system. This method meets the SLA requirements and saves energy.

In [12], they use small environmental monitoring sensors to lower the electrical costs and improve the energy efficiency. The deployed sensors can measure the temperature of the computer room while servers are running. Scheduling algorithms will efficiently arrange works for servers to lower the room temperature according to the information delivered from the deployed sensors. Their system design including hardware and software provides a good experiment for building a green huge data center.

TABLE 1 Comparison of Existing Energy Efficient Scheduling Algorithms [18]

Algorithm/ Scheduling Method	**Comparison Parameter**				
	Scheduling Parameter	**Tool**	**Findings**	**Environment**	**Type of jobs**
DENS: data centre energy-efficient network-aware scheduling (2011)	Traffic Load Balancing Energy Efficiency Congestion	Green Cloud	The proposed approach optimizes the tradeoffs between job consolidation (to minimize the amount of computing servers) and distribution of traffic patterns (to avoid hotspots in the data centre network).	Cloud	Data-Intensive Workloads (DIWs) produce almost no load at the computing servers, but require heavy data transfers
e-STAB: Energy-Efficient Scheduling for Cloud	Energy efficiency Network Awareness Quality of	Green Cloud	Load balancing and energy efficiency is achieved based on traffic load, congestion and delay are avoided.	Cloud	Data-Intensive Workloads (DIWs) produce almost no load at the computing

Computing Applications with Traffic Load Balancing (2013)	service Performance				servers, but require heavy data transfers
Task Scheduling & Server Provisioning (2013)	Energy Consumption, Task response time, Deadline	Mat lab	Results show that a data centre using the proposed task-scheduling scheme consumes on average over 70 times less on server energy than a data centre using a random-based task scheduling scheme.	Cloud	Balanced Workloads (BWs) aim to model the applications having both computing and data transfer requirements.
Minimum Completion Time Algorithm	Completion time Energy Consumption DC load	Green Cloud	The results show an improvement in the datacenter load and power consumption by using 2 phase minimum completion time algorithm to reduce the load and utilized Servers.	Cloud	High Performance Computing (HPC).
Energy efficient method using DVFS (2013)	Energy Efficiency Execution Time	CloudSim	Experimental results show that using our method is efficient in reducing the energy consumption and losing light performance of the system.	Cloud	High Performance Computing (HPC).
Benefit Driven, Power Best Fit, Load Balancing (2013)	Energy Consumption, Cost, Load Balancing	CloudSim	Power consumption is reduced and cost is reduced even more number of servers used	Cloud	Balanced Workloads (BWs) aim to model the applications having both Computing and data transfer requirements.
Green Scheduler (2012)	Energy Efficiency	Green Cloud	Power consumption is reduced by reducing the total number or servers	Cloud	High Performance Computing (HPC).
Dynamic Resource Allocation Algorithms (2012)	Energy consumption, load balancing, response time	Own written simulation environmen t that acts like the IaaS cloud system.	The energy-aware local mapping in the proposed dynamic scheduling algorithms can significantly reduce the energy consumptions in the federated cloud system.	Cloud	High Performance Computing (HPC).

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Adaptive Energy-Efficient Scheduling Algorithm	Energy consumption, Makespan	SimGrid	The algorithm can effectively save energy while maintaining a good Performance.	Cloud	Balanced Workloads (BWs) aim to model the applications having both computing and data transfer requirements.

TABLE 2. Power Saving Percentage in Existing Energy Efficient Scheduling Algorithms

Sr. No.	Table Column Head			
	Algorithm	**Power saving Percentage %**	**DVFS**	**DNS**
1	DENS algorithm	50 %	yes	yes
2	e-STAB algorithm	47 %	yes	yes
3	Task Scheduling & Server Provisioning	40 %	yes	yes
4	Minimum Completion Time algorithm	50 %	yes	yes
5	Energy efficient method using DVFS	25 %	yes	yes
6	Benefit Driven, Power Best Fit, Load Balancing	12-13 %	no	no
7	Green Scheduler	53 %	yes	yes
8	Dynamic Resource Allocation Algorithm	15-20 %	no	no
9	Adaptive Energy-Efficient Scheduling Algorithm	31.7 %	yes	no

After an in-depth analysis and investigation of the previously mentioned energy-efficient scheduling algorithms, the ability saving percentage among all algorithms was compared, as shown in Table 2. The scheduling algorithms showed a discount in power consumption in a cloud environment. As shown in Table 1, the best energy-saving algorithms were people who used both DVFS and DNS. These algorithms have power consumption within the range of 25th to 53

IV. CONCLUSION

In this paper, we presented a survey of energy-efficient techniques in cloud data centers. The related research proposals are mostly focused on energy-saving approaches for servers. However due to increasing demand on bandwidth and network connectivity of data center, energy consumption of data center network will rapidly grow in the future. Efficient scheduling algorithms play a major role in the performance of a cloud computing system. This paper studies existing task scheduling algorithms and brief analyzes every methodology. Most algorithms perform scheduling supported one or two parameters. A much better or an improved scheduling algorithm will be developed from existing ways by adding more metrics, which might end in sensible performance and outputs that may be deployed in a cloud environment within the future. This paper summarizes some existing energy scheduling algorithms employed in a cloud environment and also the power-saving percentage in existing energy-efficient scheduling algorithms. It's been determined that the most effective power-saving percentage level will be achieved by using both DVFS and DNS

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