Energy Conservation in Cloud computing - A review

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***Abstract*— In Cloud Computing, lots of energy is required to maintain the systems in a network to avoid SLA violations. Lots of energy is also consumed in cooling off the devices which is the most demanding to minimize in present scenario. Implementing green cloud and enabling low power devices and VM, avoiding the excess of energy consumption…etc. In this paper, a systematic review of existing energy consumption techniques is presented. Out of 1000 papers, 10 papers are identified reporting on power utilization techniques in cloud computing. The study concludes that all the existing techniques mainly focus on reducing power losses and SLA violations. Various parameters are also identified and these are used to compare the existing techniques. The need of green computing and the techniques used in green computing are also discussed in this paper.**

***Keywords*— Cloud Computing , Green Cloud .**

Introduction

With the advancements in technology there is a need of computing resources in IT industry. Cloud Computing is fulfilling the need of proving computing recourses in pay as per your need manner. The cloud computing refers to provide software, infrastructure and platform as a service via internet. Examples include Google Docs[1], Amazons Elastic compute cloud and simple storage services [2],Microsoft Windows azure platform [3],IBM 's Smart business services [4], Sales force .com [5],WebEx[6].In unique of its importance and benefits(such as centralizing the maintenance of software packages, data backups, and balancing the volume of user demands across multiple servers or multiple data center sites.) in IT industry, the concept of cloud has made the different organizations the Providers, Brokers and consumers. A service provider rents resources from cloud infrastructure vendors and prepares a set of services in the form of virtual machine (VM) images; the provider is then able to dynamically create instances from these VM images. The services offered by cloud computing infrastructure are responsible for dispatching these instances to run on physical resources .A running instance is charged on the basis of time it runs at a flat rate per time unit. It is in the service provider's interests to minimize the cost of using the resources offered by the cloud infrastructure vendor (i.e., resource rental costs) and maximize the revenue (specifically, net profit).From the service consumer's viewpoint, a service request for an application consisting of one or more services is sent to a provider specifying two main constraints, time and cost. Although the processing (response) time of a service request can be assumed to be accurately estimated, it is most likely that its actual processing time is longer than its original estimate due primarily to delays (e.g., queuing and/or processing) occurring on the provider's side. This time discrepancy issue is typically dealt with using service level agreements (SLAs)

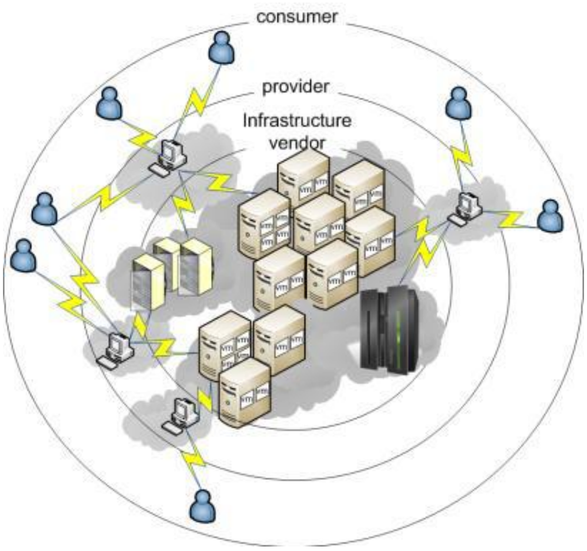

Fig : A three- tier Architecture of Cloud

Many of the computing problems such as Load balancing, proper resource utilization, bottleneck problems, Scheduling etc are solved by the cloud computing to a greater extend but still improving energy efficiency is another major issue in Cloud computing. And this has given rise to the implementation of "Green Computing ".Green computing refers to the practice of using computing resources more efficiently while maintaining or increasing overall performance. Considerable IT services require the integration of green computing practices such as power management virtualization, improving cooling technology, recycling, electronic waste disposal, and optimization of the IT infrastructure to meet sustainability requirements. Recent studies have shown that costs of power utilized by IT departments can approach 50% of the overall energy costs for an organization. And so infrastructure providers are under great pressure to reduce energy consumption. The goal is not only to cut down energy cost in data centers, but also to meet government regulations and environmental standards. Designing energy efficient data centers has recently received considerable attention. This problem can be approached from several directions. For example, energy-efficient hardware architecture that enables slowing down CPU speeds and turning off partial hardware components has become commonplace. Energy-aware job scheduling and server consolidation are two other ways to reduce power consumption by turning off unused machines. A key challenge in all the above methods is to achieve a good trade-off between energy savings and application performance.

I. RELATED WORK:

GREEN COMPUTING

As the IT industry has focused on the development and deployment of IT equipment and services that were capable of meeting the ever-growing demands of business customers. Therefore, the stress has been on processing power and systems spending. Less attention was given to infrastructural issues which include energy consumption, cooling, and space for data centers, since they were assumed to be always available and affordable. Over few years these issues have become limiting factors in determining the feasibility of deploying new IT systems, while processing power is widely available and affordable[7].The major area of concernt for IT managers are :Investment in data centers, energy cost for running and cooling them. A large enterprise data center cost from $500M to $1B, a three-fold increase since 2003 [8]..One study indicated that the cost of running data centers is increasing 20% per year on average [8].The hunt for data center efficiency has become a tactical issue [8].The high and increasing use of electricity makes data centers an important source of greenhouse gases. For information-intensive organizations, data centers can account for over 50% of the total corporate carbon footprint. For service firms, data centers are the primary source of green house emissions. Data centers, with their high energy costs and increasingly negative impact on the environment, are the driving force behind the green computing movement.

Factors motivating the Adoption of Green Computing

1) The fast growth of the Internet:

With the increase in the users of electronic data ,the size and number of data centers are also increasing resulting in the implementation of different business processes, requirements of retention of records in case of disaster recovery. Internet usage is growing at more than 10% annually leading to nearly 20% CAGR in data center demand [9].Video and music downloads, on-line gaming, social networks ,e-commerce. Industries such as financial services (investment, banking, and insurance), real estate, health care, retailing, manufacturing, and transportation are using information technology for key business functions [10]. Disaster recovery strategies that mandate duplicate records increases demand further. Finally, many federal, state, and local government agencies have adopted e-government strategies that utilize the Web for public information, reporting, transactions, homeland security, and scientific computing [11].

2 *Mounting equipment power density:*

For the high performance more server CPUs are installed which has resulted in high performance with less power consumption per CPU, packing more servers in the same footprint the form factor of servers has become much smaller, in some cases even it has shrinked by more than 70% through the use of blade servers. With this increase in the packing density power density of data centers have also increased. Density has increased more than ten times from 300 watts per square foot in 1996 to over 4,000 watts per square foot in 2007, a trend that is expected to continue its upward spiral[11, 12,13, 7].

3 Growing cooling requirements:

The increase in server power density had increased heat density in data centers relatively. Servers require approximately 1 to 1.5 watts of cooling for each watt of power used [14, 15, 16]. The ratio of cooling power to server power requirements will continue to increase as data center server densities increase.

PERCENTAGE OF POWER CONSUMPTION BY EACH DATA CENTER DEVICE [17]

Cooling Devices (chillers ,Computer Rooms Air Conditionings (CRAC)	33%+9%
IT Equipments	30%
Electrical Equipments (UPS,Power distribution units ,PDUS , lighting)	28%

4 *Rising energy costs*:

As the power consumed for the cooling of servers increases so as the cost increases. Data center expenditures for power and cooling can exceed that for equipment over the useful life of a server. a study estimated, for a typical $4,000 server rated at 500 watts, it would consume approximately $4,000 of electricity for power and cooling over three years, at $0.08 per kilowatt-hour, and double that in Japan [10]. The ratio of power and cooling expense to equipment expenses has increased from approximately 0.1 to 1 in 2000 to 1 to 1 in 2007 [7].

5) Limitations on energy supply and access:

With the need of large data centers to the companies like Google, Microsoft and Yahoo are sometimes unable to get power at any price in major American cities[18].Hence they have built data centers in the Pacific Northwest near the Columbia River where they the direct access to low- cost hydroelectricity is possible. In states such as, California, Illinois, and New York, the aging electrical infrastructure and high costs of power can stop the construction of new data centers and limit the operations of existing centers [24].In some crowded urban areas utility power feeds are at capacity and electricity is not available for new data centers at any price [19]

6. Low server consumption rates:

Low server consumption or utilization means that companies are overpaying for energy, maintenance, operations support, while only using a small percentage of computing capacity [18]. Data center efficiency is a major problem in terms of energy use. The server utilization rates average 5-10 per cent for large data centers [8]

7) Growing alertness of IT's impact on the environment:

Carbon emissions are proportional to energy usage. As lots of carbon emissions is there which causes increase in the carbon contents in the atmosphere also result in the dreadful diseases if exposed to the living organisms. In 2007 there were approximately 44 million servers worldwide consuming 0.5% of all electricity. Data centers in the server dense U.S. use more than 1% of all electricity [19]. Their collective annual carbon emissions of 80 metric megatons of CO_2 are approaching the carbon footprint of the Netherlands and Argentina [8]. Carbon emissions from operations are expected to grow at more than 11% per year to 340 metric megatons by 2020. In addition, the carbon footprint of manufacturing the IT product is largely unaccounted for by IT organizations [15].

II. Models

The Cloud computing model

A typical Could computing model shows the various elements in a cloud and their energy efficiency along with the cloud services such as SaaS ,PaaS or IaaS over Internet .From the fig it is clear that the User passes data from his device through the Internet service provider's router, which in turns connects to a gateway router within a cloud datacenter. In datacenter , Data goes from a local area network and are processed on a virtual machines, hosting Cloud services, which may access storage servers. Each of these computing and networking devices are directly accessed to serve Cloud users contribute to energy consumption. In addition,there are many devices (such as: cooling and electricity etc) other than cloud datacenter that consume power. These devices contribute indirect help in proving cloud services and are major contributors to the power consumption of a cloud datacenter.

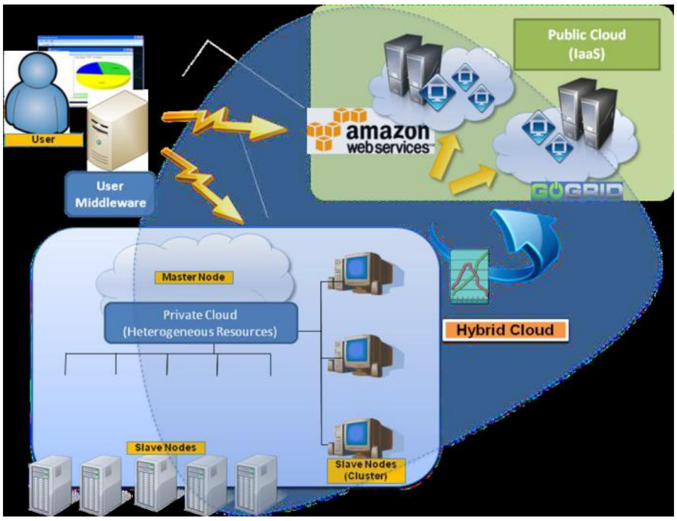

Fig : A Typical cloud computing Model

Green Cloud Architecture

Green cloud computing aroused to make a cloud better in its performance, efficiency, less power consumption and reduced carbon emission. Many things where missed in the cloud such as the size of the files on a cloud, network contribution to energy consumption in a cloud and other effects. Many work focused on just particular component of Cloud computing while others on redistribution of workload to support energy efficiency and energy cooling. In addition for the Cloud provider's profit solutions which can reduce the power consumption. A unified solution of Green Computing was proposed, which takes into account the goals of provider while curbing the energy consumption in a cloud. The high level view of the green Cloud architecture is as shown. The goal of this architecture is to make Cloud green from both user and provider's perspective.

In the Green Cloud architecture, users puts forward their Cloud service requests through a new middleware Green Broker that manages the selection of the greenest Cloud provider to serve the user's request. A user service request can be of three types i.e., software, platform or infrastructure. The Cloud providers can register their services in the form of "green offers" to a public directory which is accessed by Green Broker. The green offers consist of green services, pricing and time when it should be accessed for least carbon emission. Green Broker gets the current status of energy parameters for using various Cloud services from Carbon Emission Directory. The Carbon Emission Directory maintains all the data related to energy efficiency of Cloud service. This data may include PUE and cooling efficiency of Cloud datacenter which is providing the service, the network cost and carbon emission rate of electricity, Green Broker calculates the carbon emission of all the Cloud providers who are offering the requested Cloud service. Then, it selects the set of services that will result in least carbon emission and buy these services on behalf users.

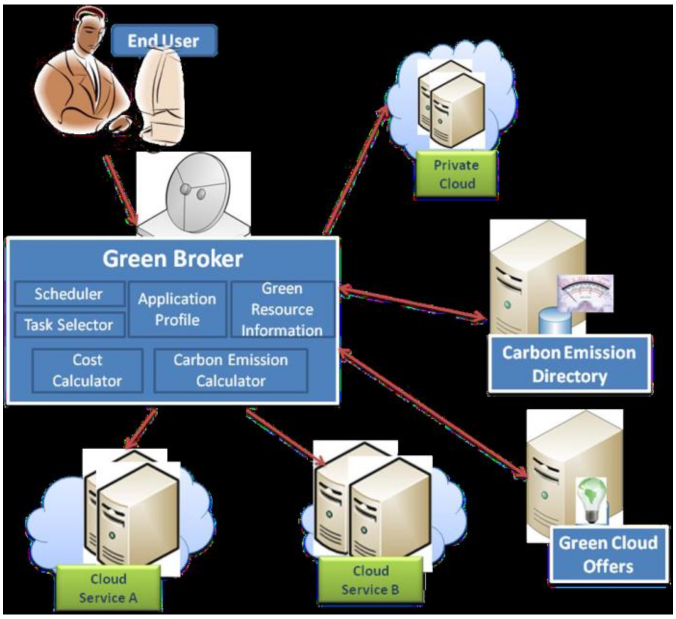

Fig: Green Computing Architecture

The Green Cloud framework is designed such that it keeps track of overall energy usage of serving a user request. It relies on two main components, Carbon Emission Directory and Green Cloud offers, which keep track of energy efficiency of each Cloud provider and also give incentive to Cloud providers to make their service "Green". From user side, the Green Broker plays a crucial role in monitoring and selecting the Cloud services based on the user QoS requirements, and ensuring minimum carbon emission for serving a user. Generally, a user can use Cloud to access any of these three types of services (SaaS, PaaS, and IaaS), and therefore process of serving them should also be energy efficient.

SaaS Level: Since SaaS providers mainly offer software installed on their own datacenters or resources from IaaS providers, the SaaS providers need to model and measure energy efficiency of their software design, implementation, and deployment. For serving users, the SaaS provider chooses the datacenters which are not only energy efficient but also near to users. The minimum number of replicas of user's confidential data should be maintained using energy-efficient storage.

PaaS level: PaaS providers offer in general the platform services for application development. The platform facilitates the development of applications which ensures system wide energy efficiency. This can be done by inserting various energy profiling tools such as Joule Sort [20].it is used to measures the energy required to perform an external sort .In addition, platforms itself can be designed to have various code level optimizations which can cooperate with underlying complier in energy efficient execution of applications. Other than application development, Cloud platforms also allow the deployment of user applications on Hybrid Cloud. In this case, to achieve maximum energy efficiency, the platforms profile the application and decide which portion of application or data should be processed in house and in Cloud.

IaaS level: Providers in this layer plays most crucial role in the success of whole Green Architecture since IaaS level not only offer independent infrastructure services but also support other services offered by Clouds. They are used for the latest IT technologies and cooling systems to have most energy efficient infrastructure. By using virtualization, the energy consumption is further reduced by switching-off unutilized server. Various energy meters and sensors are installed to calculate the current energy efficiency of each IaaS providers and their sites. Various green scheduling and resource provisioning policies will ensure minimum energy usage. Additional services during off-peak or maximum energy efficiency hours are also provided by the cloud providers.

Features of green cloud -

1 Virtualizaton :

Abdelsalam et al. [21] proposed a power efficient technique to improve the management of Cloud computing environments. They formulated the management problem in the form of an optimization model aiming at minimization of the total energy consumption of the Cloud, taking SLAs into account. The current issue of under utilization and over-provisioning of servers was highlighted by Ranganathan et al. [22]. They present a peak power budget management solution to avoid excessive over-provisioning considering DVS and memory/disk scaling .In addition, there are works on improving the energy efficiency of storage systems. Kaushik et al. [23] presented an energy conserving self-adaptive Commodity Green Cloud storage called Lightning. The Lightning file system divides the Storage servers into Cold and Hot logical zones using data classification. These servers are then switched to inactive states for energy saving. Verma et al [24] proposed an optimization for storage virtualization called Sample-Replicate-Consoidate Mapping (SRCMAP) which enables the energy proportionality for dynamic I/O workloads by consolidating the cumulative workload on a subset of physical volumes proportional to the I/O workload intensity. Gurumurthi et al. [25] proposed intra-disk parallelism on high capacity drives to improve disk bandwidth without increasing power consumption.

2. Dynamic Provisioning:

Dynamic Provsioning is essential feature of Green cloud as it is quiet difficult to predict the demand for web applications also to guarantee availability of services and maintain certain level of service quality to end users. Thus this type of provisioning helps in handling peak loads. This approach gives a better way out for implementing unutilized resources. One example of a Web service facing these problems is a Website for the Australian Open Tennis Championship [26]. The Australian Open Website each year receives a significant spike in traffic during the tournament period. The increase in traffic can amount to over 100 times its typical volume (22 million visits in a couple of weeks) [26]. Cloud providers monitor and predict the demand and thus allocate resources according to demand. Those applications that require less number of resources can be consolidated on the same server. Thus, datacenters always maintain the active servers according to current demand, which results in low energy consumption than the conservative approach of over-provisioning.

3 .Muti- tenancy:

With this approach , Cloud computing infrastructure reduces overall energy usage and associated carbon emissions. Multiple companies are served on same infrastructure. Therefore resulting in greater efficiency than multiple copies of software installed on different infrastructure .Moreover, businesses have highly variable demand patterns in general, and hence multi-tenancy on the same server allows the flattening of the overall peak demand which can minimize the need for extra infrastructure. The smaller fluctuation in demand results in better prediction and results in greater energy savings.

4 .Server Utiltization:

In general, on-premise infrastructure run with very low utilization, sometimes it goes down up to 5 to 10 percent of average utilization. Using virtualization technologies, multiple applications can be hosted and executed on the same server in isolation, thus lead to utilization levels up to 70%. Thus, it dramatically reduces the number of active servers. Even though high utilization of servers results in more power consumption, server running at higher utilization can process more workload with similar power usage.

5. Data Center Efficiency:

Power efficiency plays a major role on the total energy usage of Cloud Computing . Cloud providers can significantly improve the PUE of their datacenters. Today's state-of-the-art datacenter designs for large Cloud service providers can achieve PUE levels as low as 1.1 to 1.2, which is about 40% more power efficiency than the traditional datacenters. The server design in the form of modular containers, water or air based cooling, or advanced power management through power supply optimization, are all approaches that have significantly improved PUE in datacenters. In addition, Cloud computing allows services to be moved between multiple datacenter which are running with better PUE values. This is achieved by using high speed network, virtualized services and measurement, and monitoring and accounting of datacenter.

III Algorithm Analysis:

There are various algorithms which are analyzed in different areas in cloud computing but with the same goal of achieving energy conservation and thus support green computing directly or in directly .Here is an analyzing table which shows the different algorithms analyzed

Sr.No	Name Of Algorithm	Concept Of Algorithm	Based On Problem
1	INDU-GR(Greedy Individual Placement	Distance between Storage and Computing Application	Knapsacks
2	Pair –GR (Greedy Pairs Placement)	CPA	Knapsack And stable marriage
3	CPA-STG(Storage placement in CPA)	Storage Problem	Knapsack
4	CPA proposals and Knapsack	Iterative swapping exchanges B/w compute and storage	Knapsack
5	Energy optimization Algorithm	VM Migration	Decision making for hibernation and VM migration (yes/no)

Table : Algoritm Analyzing table

IV Energy conservation at Data center Level: Cooling, Hardware, Networks & Storage

As the energy costs,cost of saving of the existing technologies are very high thus a need of today's cloud provider's market is to adopt the best practices to get more data centers in green operations. The main challenging task is to built a green datacenters Thus many things are to be obsereved while doing so such as choosing of the location of data center, energy supply and enegy efficient equipments etc. Therefore data centers are to be constructed in a way where the renewable energy such as wind and water can be used for cooling the data centers. . Currently the datacenter location is decided based on their geographical features: Climate, fiber –optic connectivity and access to a plentiful supply of affordable energy. Since main concern of cloud providers is business, energy source is also seen mostly in terms of cost not carbon emissions. . In datacenter cooling, two types of approaches are used: air and water based cooling systems. In both they directly cool the hot equipment rather than entire room area. Thus newer energy efficient cooling systems are proposed based on liquid cooling, nano fliud cooling systems & in –server, in –rack and in-row cooling by companies such as spray cool. Another level at which datacenter's power efficiency is addressed is on the deployment of new power efficient servers & processors .Low energy processors can reduce the power usage of IT systems in a great degree. Many new energy efficient server models are available currently in market from vendors such as AMD , Intel and others: each of them offering good performance /watt system . For instance

Sun's multicore chips, each 32-thread Niagara chip, Ultra SPARC1, consumes about 60 watts , while the two Niagara chips have 64 threads and run at about 80 watts.

COMPARISON OF SIGNIFICANT CLOUD DATA CENTERS[17]

CLOUD DATA CENTER	Location	Estimated Power Usage Effectiveness	% of Energy Generation	% of Renewable Electricity
Google	Lenoir	1.21	50.5% Coal, 38.7% Nuclear	3.8%
Apple	Apple NC		50.5% Coal, 38.7% Nuclear	3.8%
Microsoft	Chicago IL	1.22	72.8% Coal, 22.3%Nuclear	1.1%
Yahoo	La Vista, NE	1.16	73.1% Coal, 14.6% Nuclear	7%

V Conclusion:

By deeply analyzing the concept of cloud computing, We conclude that although cloud computing has benefited a lot to the business organization in different and reliable aspects but it has also aggravated the carbon emission in the environment and high power consumption . According to different studies we include that the introduction to a "Green Cloud" have really reduced this to 30% but there are still many technological solutions are required to make it a reality. Mainly efforts are required in designing software's at various levels such as Operating systems, Compilers, Algorithms and applications. Also to implement green cloud datacenters the cloud providers need to understand and measure existing datacenter power and cooling designs, In conclusion by simply improving the efficiency of equipment , Cloud computing cannot be called to Green. The important part is to make its usage more carbon efficient from both users and provider's prospective also without violating the SLA.Cloud providers required to reduce the electricity demands of cloud and initiate major steps in using renewable energy sources rather than only cost minimization.

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