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A Study on Green Cloud Computing

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ABSTRACT: This disquisition explores the layered reasons and effects for the superposition of the aspects of green computing in the domain of cloud implemented storage and networking. The structure presents the dire need and existential appositeness of green computing in the present day scenario. Cloud computing has emerged as the bellwether in the field of Information Technology, on grounds of its evolving paradigm. This dissertation transcends its course through the former energy optimization techniques from the advent of cloud computing, to its present day clustered-server application. The spurt in the number of data centres to support Cloud Services, pose energy consumption and monetary issues that need to be addressed with utmost urgency. Researchers are striving to constantly come up with better and advanced techniques to enhance green computing, subsequent devising of such dispositions and techniques would overcome the prevailing vulnerabilities in this sector and pave way for the futuristic implementations of the altered technology. The scope of this paper brings out the urgency and necessity to merge green computing with cloud, energy optimizing techniques and contributing analysis proposed by researchers in this field. The modus operandi to employ energy aggrandizement and green computing have been evaluated and embellished after meticulous cloud application and infrastructure analysis.

KEYWORDS: Energy consumption; energy efficiency; cloud computing; green computing; data centers; green cloud

I. INTRODUCTION

Cloud computing is the new and rapidly spreading versatile technology, delivering computing as a utility. Cloud is a platform that provides storage services, software services, data processing, data access and other computing services through internet. Cloud Computing is an on-demand service. Major companies that provide cloud services are Google's Drive, Amazon's 'Amazon web services', Dropbox, Inc. and many more companies like Yahoo, Salesforce, Microsoft etc. are moving their data to cloud and providing diverse cloud services for its users. Since, cloud computing is becoming popular day by day and with increasing market opportunities, it is being adopted by many big companies. There is a significant increase in client-server requests that include concurrent e-commerce transactions and numerous web queries, these ever-increasing demands are met by large scale data centres which consist of thousands of servers and other infrastructure like storage units, network system and cooling facilities to avoid excess of heating up of machines[2].

Green Computing is defined as computing that is environmentally sustainable. The goal of green computing is to maximize the use of power consumption or very little or no wastage of power with efficient use of energy and to minimize the cost and CO2 emission [2]. The main purpose of green computing is to come up with solutions to make energy consumption more efficient and environment friendly. This can be done by designing new computer systems, computing models and application that have "low cost and low power consumption and promote the sustainable development of economy and society." [3].

According to Jack Newton, "Cloud Computing and environmentalism are the two most significant movements of the past decade." [7]. Although, cloud computing is considered as an energy efficient method, but recently to meet the sudden increase in end-user demands, renowned companies like Google, Yahoo, Facebook and many more are building large-scale data centres which has led to a significant increase in CO2 emission in the last decade [8]. Hence, there is need to take steps towards Green Computing to build and introduce eco-friendlier and environmentally sustainable systems and methods.

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In this paper, we'll discuss the necessity of green cloud computing in section 2. Section 3, discusses about the related work done by researchers to implement green computing. Various energy saving techniques are discussed in Section 4. Section 5, concludes the paper.

II. RELATED WORK

In 2010, according to Greenpeace [9], "2010 has been touted by many in the ICT sector as the 'Year of the Cloud'." Also, according to Greenpeace's "Smart 2020 Analysis" [9], "global carbon footprint of the main components of cloud-based computing - data centres and the telecommunications network - would see their emissions grow, on average, 7% and 5% respectively each year between 2002-2020. Underlying this analysis is the number of data centre servers growing on average 9% each year during this period.".

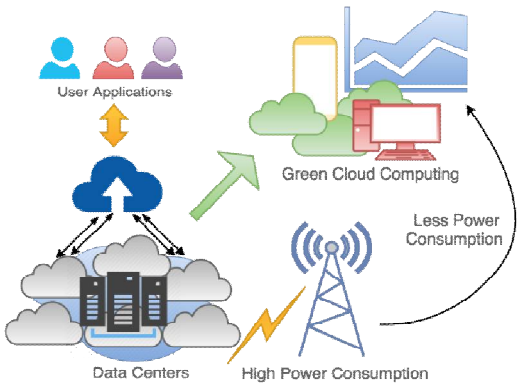

Fig. 1. Green Computing for sustainable environment

Figure 1, illustrates an everyday scenario of client-server interaction (user application and data centre) and benefits of moving to green cloud.

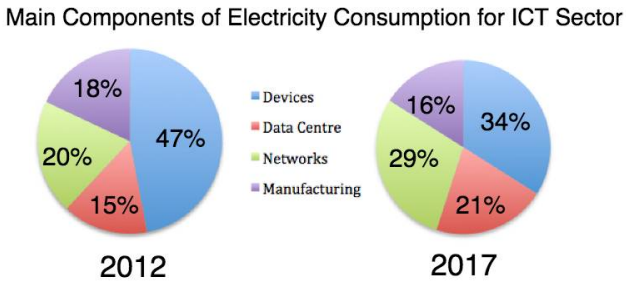

Fig.2. Electricity consumption by main components in ICT sector

Figure 2, graphically depicts the analysis of Peter Corcoran and Anders Andrae for "Emerging Trends in Electricity Consumption for Consumer ICT" [15]. Evaluating data, field records, and prior researches, the authors have hypothesized that by the year 2017, the electricity requirements of the cloud Data Centres will have reached a staggering 21%. This is an alarming conclusion, which would contribute to enormous amounts of carbon dioxide emission in our already hampered environment.

Numerous applications are run by data centres that work under cloud computing. Some data is processed within seconds, whereas, large data feeding on shared hardware platform takes more time to process. The cloud computing on-demand facility faces challenges when diverse data is to be processed, one by one or concurrently. Resource and time allocation is must to avoid delay and production of erroneous results [9].

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Data centres are unavoidable, they are needed for data storing, accessing, processing and other services. The rate of energy consumption is alarmingly high, and the major downside to this consumption is that, only a small fraction of this energy is actually used to produce an output. The data centres are spendthrift to keep up, the additional infrastructure like coolers, to maintain the temperature of large number of servers inside a data centre, adds to the cost as well as the carbon footprint. Green cloud computing helps with the convoluted process of achieving reduction in energy consumption amidst efficient use of infrastructure.

III. ENERGY SAVING TECHNIQUES THROUGH CLOUD COMPUTING

Cloud computing employs numerous techniques at different strata to optimise energy consumption. These may be enlisted as:

A. *Server Virtualization:*

Server virtualization is the masking of server resources. It allows for division of one physical server into multiple isolated virtual environments, consequently enabling concurrency of multiple operating systems, processors and server users. It is a careful implication of virtual server consolidation, with drastic minimisation of the server as a physical entity, promoting the agenda of green computing [4].

B. *Dynamic Server Provisioning and Load Dispatching:*

Dynamic Server Provisioning deploys numerous manners to switch off any redundant hosts [5]. Hibernating the idle servers promotes minimal number of servers to function, along with meticulous load dispatching techniques which leads to utmost energy optimisation and load distribution for operational servers.

C. *Operating System-Processor Scheduling:*

In order to bring out maximum resource utilization, scheduling is incorporated not only at a horizontal level, but along the vertical axis as well. The Rate Monotonic Scheduling targets energy conservation using the Dynamic Voltage Scaling (DVS), but at the price of CPU speed, due to which an amalgam of DVS and memory aware scheduling is put to practice.

D. *Advance Clock Gating Common:*

Access permissions for an individual logic block is granted by activation of its respective clock. The toggling of such a clock is monitored by a hardware implemented clock gater that activates a clock only on receiving an initialization request. This accounts to substantial reduction in dynamic power dissipation by engaging itself in synchronous circuits, as well as global asynchronous circuits, where they are included in locally synchronous blocks [1].

E. *Rectifying Cooling Methodology:*

One of the most disregarded, yet a predominant parameter in power conservation is cooling. Traditional inefficient, small scale cooling without in-house professionals is being rapidly replaced by advanced, continuously optimized, and highly efficient cooling systems that lay emphasis on a clustered inlay of operations rather than the host-specific coolants.

F. *Targeting Network Infrastructure in Cloud:*

Storage and computational aimed energy minimization has led to major a compromise in the Network Infrastructure energy management. As per ICT energy estimates, in various access systems like the radio, the network has been found accountable for majority of cost recurrence and energy consumption. The order of these numbers have been found comparable to those of the total expense of the personnel employment [6]. Various measures, like the

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Geographic Adaptive Fidelity Protocol are therefore introduced to counteract such effects and stabilise energy dissipation due to network infrastructure.

IV. RELATED WORK

There have been many works and contributions in the field of green cloud computing to enhance its applications in real life scenarios.

Truong Duy, Sato and Inoguchi ,[10], presented a "Green Scheduling Algorithm" in combination with neural network based predictor to save energy in cloud computing. It makes prediction to turn servers on/off depending on the pre-collected data. Hence, depending on the prediction of load demand, it minimizes the number of servers running.

Fumiko Satoh, [11], developed an "Energy Management System" for future energy management using "sensor management function with an optimized VM allocation tool", the results show that this will help in reduction of energy consumption up to 30% in multiple data centers and reduction of energy in carbon emissions.

RasoulBeik, [12], for calculating energy consumption in data centers proposed an "energy aware layer in software – architecture", and also provides energy efficient services to user.

Rocha and Eleri Cardozo, [13], proposed a "Hybrid Optimization Model" for Green Cloud Computing, produces "nondominated solutions" that allow the cloud provider to select the better bargain in terms of energy consumption and Network Quality of Service. Another advantage of this strategy is best routes are provided to the network traffic via constraint-based routing techniques. These routes are energy efficient and maintain QoS.

Garg, Yeo and Buyya et al., [14], presented a "Carbon Aware Green Cloud Architecture", to improve the carbon footprint of cloud computing. It consists of three elements Third Party: consist of two directories "Green Offer", for available green cloud services and "Carbon Emission", for energy efficiency of those services. User: "Green Broker" selecting the greenest cloud service provider. Provider: "Green Middleware" that provides the greenest or energy efficient service. Its components may vary according to SaaS, PaaS or IaaS.

B. Priya, E. S. Pilli and R. C. Joshi et al. [16], put forth "A Survey on Energy and Power Consumption Models for Greener Cloud", which gauged energy efficiency effects by implementing green computing in cloud-based services. The paper focused at minimizing power dissipation and carbon dioxide emissions to heighten the effect of green computing. The research lays emphasis on three primary parameters to make any cloud energy efficient. The first one being, Virtualization; the second being Load Dispatch by Server optimization and lastly, Software Automation. Along with these criteria, precision enhancing factors such as pay-per-use and clock gating have also been included.

D. Kliazovich and P. Bouvry [17], presented their analysis in "Green Cloud: A Packet-level Simulator of Energy-aware Cloud Computing Data Centers" highlighted the steady increase in cost of cloud data centers maintenance due to the respective operations done in cloud. The study aims at identifying the need of optimum distribution of workload among the available servers and data centers to develop an energy consumption metric in terms of packet level. This allows for packet level communication and convenient synchronization of operations. The NS2 simulator, for green cloud; and "cloudism" for cloud only, are a few instances of packet level simulators employed to achieve the simulation, which is done at three levels, "two-tier, three-tier, and three-tier high-speed data center architectures".

M. Kaur and P. Singh [18], in their research paper "Energy Efficient Green Cloud: Underlying Structure" tackled various challenges in the domain of energy efficiency for the cloud. On account of the various gases emitted in the environment, the authors devised a model to evaluate the energy wastage in the sector. The proposed model takes into the account the Virtualization of resources, in addition to the expansive data analysis, and field studies to bring out a greener effect on use of the green cloud.

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L. Hosman and B. Baikie [19], via the "Solar-Powered Cloud Computing datacenters", pinpointed a then overlooked vulnerability, attributed to the energy hungry data centers and the discontinuous availability of this energy. To counteract this issue, the idea of Solar Energy was arisen, and how it could alter the shape of the prevalent energy management techniques. A miniaturized cloud data center was hence proposed that combined the essentialities of energy conservation, less power consumption platform and DC power distribution for heightening energy efficiency in cloud computing.

V. CONCLUSION

Mother Nature doesn't approve of our steps and methods towards modernization and advancement. We have to keep in mind that the fulfillment of ever-increasing demands should not be on the cost of nature. Cloud computing is the new trend and its rampant success has led to companies building numerous data centers to host cloud apart from what already existed for other IT purposes. IT sector contributes about 2% of the total CO2 emission on earth. Green Cloud Computing comes into picture when Green Technology is combined with Cloud Computing. This is to make cloud computing more environmentally sustainable. Energy saving techniques, low power consumption and low cost are the main aim of green cloud computing and hence, aid and encourage towards promotion of sustainable development of society and economy.

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