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A Review on Energy Efficient Load Balancing Algorithm Using Cloud Computing

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Abstract

As it provides utility-oriented services based on a pay-as-you-go model over the network, cloud computing is now the most developing area. Large organisations are moving their workloads to the cloud as a result of the availability of scalable on-demand resources and the supply of services globally. The amount of energy consumed by the data centres that host these cloud computing applications has significantly increased due to the growing demand for cloud services and high data centre usage. High operational costs and environmentally unfavourable carbon footprint emissions are caused by data centres' high energy usage. In order to minimise the high operational cost and also to decrease CO_2 dissipation, we must emphasise and research numerous green cloud computing solutions. In order to decrease energy usage, this study explores a variety of energy-efficient strategies. Additionally, comparative research is done to recommend improved future initiatives.

Keywords: Datacenter, Cloud Computing, Energy, Green computing, Consumption

1. Introduction

Cloud computing is internet-based computing; data centres use a network of remote servers that are hosted on the internet for the storage, management, and operation of local servers as well as computers. It allows users to instantly exchange data and resources with any PCs or devices. Three different approaches to the cloud services layer are provided by cloud computing namely:

- The infrastructure is known as the IaaS service (IaaS).
- The platform is known as the PaaS service (PaaS).
- Software is known as SaaS services (SaaS).

These three service tiers support governmental and commercial institutions in lowering operational costs. IaaS offers services that allow users to manage their operating systems. IaaS offers services like Microsoft Azure, IBM Bluemix, and Amazon Web Services. The client introduces or develops its own unique working frameworks, programming, and applications; it merely provides the equipment and system. PaaS offers a platform for creating apps with the aid of the cloud; if the user is using it on their own system, there is no need to install any platforms. PaaS services like Google App Engine and Windows Azure. It offers the workspace, together with the necessary tools and operating systems; the client then introduces or develops their own applications using a particular programming language. SaaS for running already-existing programmes like Instagram, Facebook, and Google Apps, where users don't need to worry about handling any software

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, Dec 2022

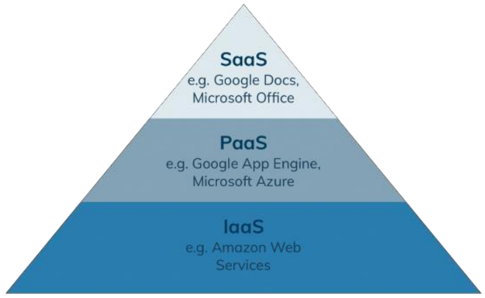

Figure 1: Services of cloud computing

Green cloud computing

To meet the expectations of consumers online and on time, the cloud contains hundreds of data centres, and as a result, data centres are spread over an area of several hundred to several thousand feet. The power needed to run these servers is enormous. Thus, green cloud computing [1] is envisioned to not only accomplish efficient processing and use the computing infrastructure, but also to reduce energy consumption that has a greater negative impact on the environment. For cloud computing to be sustainable and environmentally benign in the upcoming year, green cloud computing is crucial. Large corporations like Google, Amazon, and IBM employ green clouds because they allow customers to access services from any location. Because it offers large resource pools that users can purchase as needed, green cloud computing is an on-demand service. In their paper, Wadhwa and Verma [2] analysed the work of numerous researchers and their methods for improving the energy efficiency of cloud computing and lowering carbon emissions from the environment. They discovered that virtualization can aid in the efficient use of resources in clouds.

2. Classification of Energy-Efficient Techniques

The author discusses the numerous energy-efficient methods put forth and used in earlier research studies in this part. The numerous methods and algorithms that scholars have discussed to reduce data centres' power usage.

A. Virtualization

Using live VM migration strategies to maximise energy efficiency, virtualization technologies are enhancing cloud performance. In a cloud computing setting, VM migration is a highly helpful tool that may be used for load balancing, fault management, system maintenance, and lowering data centre energy usage.

One instance of an operating system known as a "VM" is one in which at least one application is executed in a separate partition on the PCs. A single physical machine can house several virtual machines. It is necessary to move a physical machine's load to another one if it increases. Virtual machines are moved from one physical machine to another physical machine using an image file in a process known as virtual machine migration. Previously, to do the same task, VMs had to be turned off before the necessary resources could be assigned to the new physical computer. Following the migration of VM files from the source to the destination machine, the VM is subsequently started on the new destination machine. However, the live migration does not adhere to this strategy [3]. Without any downtime, VMs migrate during live migration. Virtual CPU, memory, and device internal states are all sent along with the virtual machine state. The

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, Dec 2022

maximum permissible level of CPU utilisation. Additionally, three migration policies are used, including minimal migration to cut costs, moving the VM with the lowest CPU usage, and moving the required number of VMs in accordance with a uniformly distributed random variable. An experiment using these policies on CloudSim demonstrates that the energy consumption was reduced by 1.48 KWh when VMs were allocated dynamically while adhering to a minimal migration policy. However, energy consumption is further decreased to 1.14 KWh if SLA is loosened. In order to increase server utilisation while reducing cost, A. Kochut and K. Beaty[3] have proposed a scientific model of the VM migration process, the predictability of work-load, and dynamic control of resource utilisation. They also explored how to manage resource demand dynamically using traditional forecasting time-series modelling methodologies. The major goal of the suggested strategy is to maximise server utilisation by increasing the demand on the machines that are already running, as opposed to turning on brand-new machines. Thus, while raising the workload on existing computers won't further increase power consumption, waking up new machines can significantly increase power consumption. This notion can thereby boost the utilisation of machines. By turning off idle nodes, VM consolidation is regarded as one of the effective methods for lowering energy use. By moving the underutilised VM to another VM, this is accomplished. The migration primarily takes into account some thresholds and CPU power utilisation. The 0-1 knapsack dynamic algorithms were suggested by Jing Huang et al.[6] to minimise the migration cost and switching cost by lowering the number of migrations. Due to the expense of the network devices that connect the source and destination hosts, as well as the expense of bringing the destination VM out of sleep mode, anytime we migrate the VM. Results demonstrate lower energy consumption and SLA violations. The importance of virtual machine migration in assessing cloud centre performance. Pre-copy and post-copy virtual machine migration approaches were described by Narander Kumar et al. [7]. Analysis shows that pre-copying is more effective than post-copying because there is little to no downtime. However, when a task necessitates so many copying cycles in order to reduce the number of defective pages, the system's performance and QoS are negatively impacted, and a lot of bandwidth is used. As a result, the author suggested a framework to reduce copying cycles in order to optimise speed while using less energy. Green cloud computing is becoming more and more necessary in order to produce energy-efficient solutions by reserving energy over time through mechanisms like recycling and reuse. As a result, effective resource optimisation using eco-friendly methods is required. The idea of managing cloud environments in an energy-efficient way was covered by R. Buyya et al. [8]. With the goal of achieving high service quality, high performance, and cost savings, they introduced a dynamic resource provisioning and allocation algorithm based on modified best fit reducing, minimization of migration, and power management.

B. Task Scheduling

One of the most efficient strategies to reduce energy consumption in a cloud environment is to intelligently schedule the jobs. An artificial bee colony scheduling approach was recommended by the research paper's author [9] for achieving energy economy with optimal job response times in a cloud setting. This meta-heuristic method draws inspiration from how bees naturally behave when looking for food. This behaviour is used to assign jobs to the server in order to solve the difficult problem and iterate until the best solution is discovered. Consequently, this strategy offers

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less and taking less time to process than conventional scheduling algorithms. The author of [12] has suggested an Ant colony system strategy employing OEM local search techniques for the virtual machine placement problem. The artificial ants assign the VMs based on the data from the global search. OMEACS keeps track of VM history, uses that information to distribute pheromone among the VMs, and conducts local and global searches, all of which help to effectively solve big issues. Compared to other heuristic algorithms, this method efficiently uses the machine and reduces the number of active physical servers.

C. Renewable sources of energy

The demand for energy resources is rising quickly as a result of increased use of ICT equipment in many industries. Due to the limited availability of fossil fuel energy sources, a transition to renewable energy sources like solar, wind, and hydroelectricity is necessary. The need for a constant power supply and the demands of elastic and dynamic clouds provide data centres with their greatest problems. One of the first significant initiatives to provide ICT services based only on renewable energy sources including wind, solar, and hydroelectricity globally was The Green Star Network (GSN) programmes [13]. According to estimates, RES produced 9.3 percent of all domestic electricity in the US in 2009, 10.2 percent in 2010, and 12.7 percent in 2011. Google is one of the leading IT businesses to enhance its use of renewable sources of energy, along with other top companies. An estimated 39 percent of the electric power capacity added by wind power in 2011 was from RES[14]. The variable and intermittent nature of renewable energy sources presents a difficult problem. Solutions for utilising renewable energy in a cloud context were covered by Deng Wei et al. [15]. A model for energy generation suggested using renewable energy sources like solar and wind. Another model mentioned is the Prediction model, which forecasts energy production while allocating workloads in accordance with the demand and supply of renewable energy at the time. Last but not least, data centre capacity planning is covered, including a variety of renewable options, including onsite and offsite options, various energy storage devices, weather conditions, market price fluctuations, workload variance, incentives, and service agreement penalties, which should be taken into account by datacenter planners. A mathematical framework and an algorithm for workload allocation based on optimisation were developed by Ghamkhari et al.[16] to distribute various tasks in a variety of data centres in order to consume less energy. The decision of where to move the task's data centre is made based on the availability of renewable energy sources and the lower cost of power usage. This suggested approach lowers the price of data centres, cuts carbon emissions, and upholds QoS.

D. Power Management Techniques

By controlling the power supply of the virtual machines, the energy consumption of the computing systems can be decreased. There are two types of power management: static and dynamic. Static power management, which primarily focuses on lowering the switching activity power of the circuits, is done at the design, circuit, architecture, and system levels. When the system is in the running state, dynamic power management (DPM) techniques are used. One of the most popular DPM strategies, dynamic voltage and frequency scaling (DVFS), lowers power consumption by consumption and dynamic power usage. Dynamic Voltage Frequency Scaling, or DVFS, can help to solve the issue of energy waste. By supplying dynamic voltage, it is one of the methods used to lower the power consumption of virtual environments in data centres. The power-saving approaches of DVFS and DPM were explored by D. Kliazovich et al. [19]. In order to improve energy efficiency, it assesses the scheduling strategy based on workload concentration. The hardware and other computational resources needed to fulfil the request are estimated. It suggests developing energy systems with lower power usage. The evaluation's findings indicate that the suggested methodology can, on average, save up to $750 per year. Energy-efficient workflow was suggested by Zhu Tang et al. [20]. Dynamic voltage frequency scaling (DVFS) technique is the foundation of the task scheduling algorithm (DEWTS). It can be used in a variety of parallel applications in a distributed setting with diversity. It distributes the task in free slots with low voltage and frequency and mostly leverages the slack time when the servers are combined. The evaluation's findings demonstrate that the suggested approach balances scheduling performance while cutting power consumption by up to 46.5%.

E. Service Level Agreement

An agreement known as a Service Level Agreement (SLA) is made between the service consumer and service provider to ensure that both functional and non-functional needs are met. It is an official legal document that details the calibre and price of the services being rendered. SLAs are not just used to ensure client satisfaction; they also help service providers manage their infrastructure more effectively. Only in 2011, according to estimates, did energy usage in data centres throughout the world rise by 19%. The fact that virtual machines and other computer resources are over-provisioned is one of the key causes of this high level of energy usage. The energy usage of data centres can be decreased using a variety of operationally sound strategies. However, a lot of them have a detrimental impact on the quality of service (QoS) of the jobs that have already been stated in SLA. As a result, this issue is solved by energy-conscious SLAs, also known as Green Service Level Agreements (GSLA)[21]. The overall negotiation structure included in the GSLA has been designed with an approach that aims to minimise energy use. A Green SLA service was suggested for HPC cloud service providers by Haque Md E. et al. [22]. The percentage of energy that will be used to run a work must first be specified by the customer as a GSLA. The providers will be panelized if they continue to break the SLA standards after accepting the project. The author has developed an optimised scheduling framework with power distribution and control infrastructure strategy to achieve this. It's not necessary to approach every customer with the same negotiation strategy, though. Since each user has a unique set of requirements, various factors were taken into account when developing these negotiating policies. Consequently, these policies will benefit environmentally concerned shoppers. For applications with precedence constraints, Chen et al.'s energy-aware scheduling algorithm (EASLA) has been proposed [23]. By dynamically scaling their frequencies and distributing the slack to the non-critical jobs, the suggested algorithm reduces energy consumption. Due of interconnections between activities, slacks were only occasionally employed in the past. However, the EASLA method saves more energy by allocating the slack to improve parallelism and identifying the greatest number of independent jobs. With the help of this framework, consumers can negotiate with service providers to reduce energy use while maintaining quality of service (SLA).

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, Dec 2022

The Plug4Green architecture was proposed by Dupont Corentin et al. [24] and uses a set of SLA restrictions to offer consumers energy options. Two events, namely Single Allocation and Global Optimisation, are used in this architecture. When a new VM is to be allocated, the first single allocation event is initiated. As a result, it assigns the VM to the best server by taking into account the VM's attributes, the server's current status, and the SLA. The global optimisation event, however, is carried out on a regular basis. With this strategy, the provider can deliver energy- and CO2-emission-optimized outcomes. Overprovisioning of power-hungry virtual machines is the primary cause of energy consumption in cloud data centres. A negotiation method based on particle swarm optimisation was created by Copil Georgiana et al. This method leverages the Web services agreement specifications to deliver the SLA negotiation, which will encourage the user and service provider to reduce resource allocation and aid to achieve the optimised energy consumption.

F. Hardware-oriented optimizations

The computers, cooling systems, network setup, and other components of the data center's IT infrastructure. Because any system failure can result in downtime and a degradation of client services, data centre maintenance is crucial to ensuring their effective operation and dependability. The performance of an IT system in a data centre is heavily dependent on the cooling systems, hence precise cooling solutions must be developed to reduce heat dissipation. Maintaining networking configurations, using parallel architectures, managing frequency, and voltages in servers that effect energy use are further ways to reduce energy consumption.

3. Energy Management

Despite the fact that cloud datacenters are intrinsically energy-efficient platforms, huge quantities of power are nevertheless used by datacenters due to resource sharing by hosted apps and more effective resource usage [25]. Cloud workloads are anticipated to more than triple from 2015 to 2020, as has the demand for cloud services and the need for more computing resources. Because of this, massive computing datacenters that use a lot of electricity have been built. High power consumption produces a lot of heat, which may affect the dependability of hardware and put more strain on cooling systems, which can consume as much electricity as computer equipment. Global datacenters produce a sizeable amount of CO, with emissions expected to increase 7% annually. In essence, high power consumption has a negative impact on operational expenditure (opex), which manifests itself in the form of higher electricity bills, cooling needs, reliability, and excessive carbon dioxide emissions. By 2020, it is anticipated that datacenters will consume 8% more electricity than they did in 2010 (1.3% of total consumption) [26]. Energy costs for datacenters are expected to total $27 billion yearly.

New datacenters may be built or the capabilities of existing datacenters may be increased to suit the growing demand for cloud services. However, due to financial and physical limitations like set capacity of power generating facilities and a restricted potential server density, extending datacenter capability is not always possible. The total cost of ownership (TCO), which includes both the capital expenditure (capex) needed to build a new facility and the operating expense (opex) needed to run the datacenter, can cost millions of dollars to build new datacenters. Investigating and locating inefficiencies in order to enhance the capabilities of current facilities is an alternative to constructing new datacenters or expanding existing ones.

3.1 Causes of Energy Inefficiency

The costs related to a datacenter's energy use may be higher than necessary for a number of reasons. The main cause of energy loss or waste in datacenters is the poor use of energy by individual components [27]. Energy given to the system that is not immediately utilised by computer operations is referred to as energy loss. Examples include energy loss from power delivery and conversion, cooling, lighting, etc. Typically, the

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, Dec 2022

Power Usage Effectiveness (PUE) metric is used to calculate energy loss. The PUE statistic compares the amount of energy used by a facility as a whole to the amount used by just its IT equipment (such as servers, network equipment, and storage devices). Figure 2 depicts the typical energy consumption distribution in a typical datacenter with a PUE of 2. A PUE of 2 means that the datacenter uses twice as much energy as is required to just power the servers, or that 50% of the facility's total power is utilised for IT equipment and the other 50% is used for overhead.

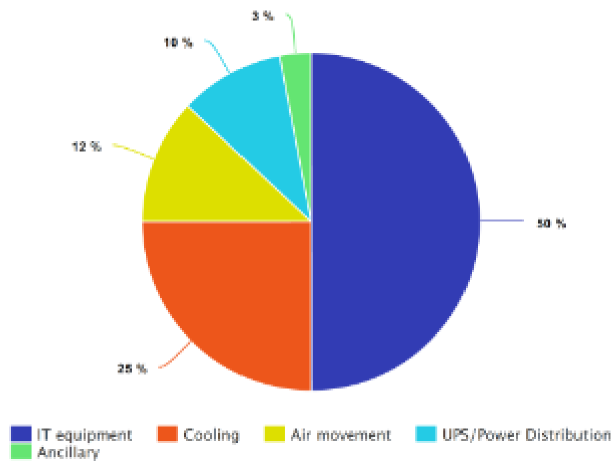

Figure 2: Main sources of power loss in a legacy datacenter [27].

The PUE for a state-of-the-art datacenter is often under 1.2, despite the average PUE for conventional datacenters being around 1.8-1.9 [27]. Due to meticulous engineering, auxiliary systems like cooling and electricity distribution systems have lower PUE values. Industry leaders in energy efficiency, like Google, have used effective hot-cold-aisle separation, optimised cooling (using free cooling resources like cold outside air and large bodies of water), and highly efficient power conversion systems and uninterruptible power supplies (UPSs) (using distributed UPS solutions for effective AC-DC-AC conversion) [27]. Since energy loss has been significantly reduced, enhancing the energy efficiency of a cloud datacenter now relies on enhancing the effectiveness of the use of IT equipment, which we go into more depth about below.
Energy waste is the term used to describe the energy used by IT equipment that does not produce any meaningful results, such as the energy used by servers that do not produce any productive work. One cause of this waste is the fixed amount of electricity that is often installed in server racks based on planning for the worst-case situation. Since servers often consume considerably less power than what they are allotted, such over-provisioning results in inefficiencies. Limiting power can improve utilisation of available capacity and rack density, but it can also cause performance issues for applications with different performance needs [28]. Low utilisation of IT resources in datacenters is another factor contributing to energy inefficiency. According to an investigation of a cluster at Twitter with thousands of servers, only 45% of the available memory was utilised, and the average CPU utilisation was under 20%. For facilities that do not pool workloads, utilisation estimates are much lower (5–12%). Low utilisation in a cloud infrastructure can be attributed to a number of factors, such as performance isolation issues, coarse-grained resource allocation, and over-provisioning of resources to keep applications responsive despite fluctuations in user numbers. Because general-purpose servers in datacenters don't utilise energy proportionally, low resource utilisation results in poor energy efficiency.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, Dec 2022

3.2 Energy Proportionality

A energy proportional system, in theory, would not use any energy when it was inactive and would use more energy according to its level of activity. Although most general-purpose computing systems, such as servers used in datacenters, do not have energy-proportionality (EP), their performance per watt does not decline linearly with load. As demonstrated in Figure 3, a server, for instance, may consume more than half of its peak power when idle [29].

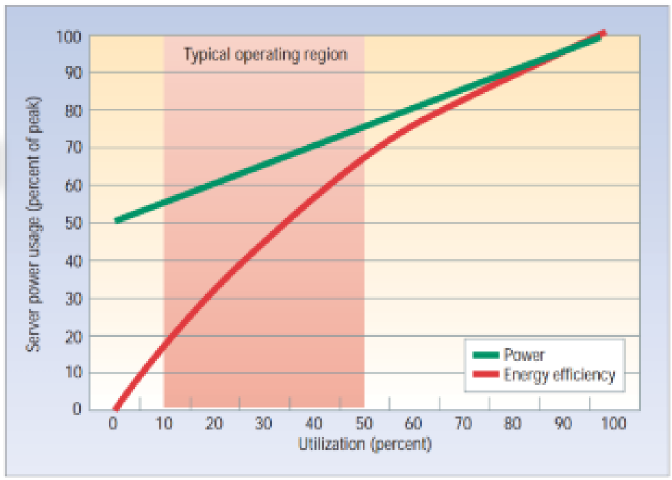

Figure 3: Server power usage and energy efficiency at varying utilization level [29].

It is possible to handle EP at the hardware, software, or both levels. Hardware approaches aim to increase the EP of each of a datacenter's individual computing, networking, and storage operations. Improvements to hardware design such as CPUs with many cores, throttling, voltage drop, DRAM chip voltage level decrease, disc spin, network topology modification, and dynamic routing are examples of such strategies. Despite the fact that computer systems are now more energy proportionate than they were in the past (EP increased by a factor of 2.8 between 2008 and 2012), considerable advancements are still needed, especially in memory, disc, and network subsystems, to attain EP in cloud datacenters. Over the years, a number of software-based methods (some utilising hardware capabilities) have been suggested to further enhance EP. Component-level, server-level, and cluster-level approaches can all be grouped together. Component level strategies make advantage of techniques such core heterogeneity, dynamic voltage and frequency scaling (DVFS) for CPU and memory [30], idle modes, and idle modes. The usage of full system low-power modes and server heterogeneity have been the main focuses of server-level methods. Consolidation is one cluster-level strategy that has focused on turning off idle servers while running fewer servers at heavy load. Although component-level DVFS approaches typically scale the frequency and voltage of components in accordance with utilisation levels, SLO breaches might occur when users are unaware of the performance needs of applications. Furthermore, these techniques are difficult to adapt for usage in virtualized systems, as VMs running on the same host may have wildly divergent performance needs. To make energy management more cognizant of QoS needs, a more adaptable approach is required, incorporating a performance-aware DVFS model and optimisation algorithms. For the needs of cloud datacenters, server-level solutions that emphasise the utilisation of full-system idle power modes are not particularly suitable. Online services in particular are latency sensitive, rarely operate in a near-zero idle state, and have dynamic resource requirements, which means the relatively long wake-up times that result from changing power modes may result in SLO breaches [32-35]. Additionally, full-idling times are becoming less common because separate cores in a multi-core

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Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, Dec 2022

server have independent idle periods that hardly ever overlap in time. Modern datacenters are not suited for cluster-level solutions that depend on condensing services onto fewer servers to increase system utilisation. Due to the high costs of migration in terms of time and resource utilisation, interference, and large traffic spikes, consolidation could cause performance issues. Additionally, services may make advantage of a dataset split among hundreds of nodes or seek to maximise memory usage for data caching between nodes.

4. Cloud Computing Issues and Challenges

4.1 Issues

An old idea has a new name: cloud computing the provision of computing services from a distance. When pooled resources, software, and information are made available to computers and other devices on demand over the cloud, it is referred to as Internet-based computing [31].

Major problems with cloud computing include these:

1. **User data privacy:** The host company has access to the user data with or without the user's consent. The data stored in the cloud is always accessible to the service provider. They might unintentionally, purposefully, or even maliciously erase material.
2. **Compliance:** Data and hosting are subject to a number of laws and regulations. The user may be forced to employ pricey deployment techniques in order to adhere to requirements (such as the Federal Information Security Management Act and the Health Insurance Portability and Accountability Act).
3. **Security:** Third parties provide storage and security for cloud-based services. When using a cloud-based company's services for a very cheap or no cost, can one assume that their data would be protected and secure? They might divulge user data to third parties. A significant threat to the cloud is security.
4. **Sustainability:** This concern relates to reducing the environmental impact of cloud computing. Citing the server's effects on the environmental implications of cloud computing, the countries with favourable conditions, such as Finland, Sweden, and Switzerland are those where the climate favours natural cooling and renewable electricity is easily accessible and are trying to attract cloud computing data centers. But aside from the assistance of nature, do these nations possess the necessary technological infrastructure to support the premium clouds?
5. **Abuse:** It is important to make sure that clients aren't using cloud computing for illegal purposes before offering cloud services. In 2009, a banking Trojan utilised the well-known Amazon service unlawfully as a command and control route to distribute malicious software upgrades to victim PCs. Therefore, appropriate precautions should be taken by the hosting firms and the servers to address these difficulties.
6. **Higher Cost:** If your organisation is broad and huge, a standard cloud service subscription won't work for you. Additionally, if you want to use cloud services continuously, you'll need a strong network with more bandwidth than typical internet networks. This is a significant issue for small businesses, preventing them from utilising cloud technology for their operations.
7. **Recovery of lost data in an emergency**: Before signing up with any cloud service provider, review all applicable regulations and documents to ensure that their services are in line with your needs and that the infrastructure is sufficient, well-kept, and properly maintained. After signing up for the service, you almost gave away your data to a third party. If you are able to select a suitable cloud service, you won't have to worry in the future about recovering lost data in any unforeseen circumstances.

8. **Cloud maintenance** (management) Because a cloud architecture includes a massive infrastructure of resources as well as other problems and dangers, user happiness, etc., maintaining a cloud is a herculean undertaking. Users typically pay according on how much of the resources they have used. Therefore, it can be challenging to determine how much to charge when a user requests scalability and an expansion of the services.
9. **Resources and skilled personnel are in short supply**. This is one of the main problems facing businesses and organisations today. Every other company seems to be considering using cloud services or has already done so. Because of this, the workload in the cloud is growing, necessitating constant rapid innovation for cloud service hosting organisations.
   These considerations make it difficult for organisations to stay current with the tools. More competent and qualified workers are required because new tools and technologies are being developed daily. Only by providing IT and development workers with further training will these difficulties be reduced.
10. **Pay-per-use service fees:** A user can expand or compress the volume of a resource in the cloud depending on their demands. As a result, you paid according to your resource consumption. It is challenging to determine a specific pre-defined pricing for a specific amount of services. The deployment of cloud computing is extremely challenging and complex due to these types of ups and downs and pricing changes. The owner of a business must work hard to analyse seasonal and other swings in demand as well as constant demand. Therefore, creating a budget for a service that could gobble up several months of the budget in a few days of intensive use is challenging.

4.2 Challenges

The challenges of cloud computing is described below:

1) Adequate Security: Since cloud computing is a relatively new technology and many startup businesses use it, it draws a group of people who want to intentionally attack the network and steal valuable data. Data security is one of the major challenges. The organization's data and software are seriously harmed by security problems like data loss, botnets, and phishing [36].

2) Sufficient Performance: Cloud computing suffers from some of the same problems that plague the internet as a whole. As a result, the cloud's ability to provide effective service will be limited. The presence of some malevolent attackers on the network increases network traffic, which hinders the cloud's ability to operate effectively.

3) Cloud computing is affordable: Pay-per-use services are a crucial component of cloud computing. Today, the majority of businesses are transferring their data to the cloud. Data transfer into a private cloud is more expensive because the price is determined by how much data is transferred per unit.

4) Service level agreements (SLAs): The cloud computing user is unaware of the service quality, performance, and availability. The greatest cloud services must be made available to customers by the service provider. As a result, there is an understanding between the service provider and the client on the accessibility of the good services. The difficulty here is that there are occasions when agreement is not evident. As a result, the agreement is very appropriate and straightforward, and it meets all of the consumer's needs [36].

5) Charging Model: Traditionally, data centres bill customers based on how much computer power they use. However, the flexibility of the resource pool in cloud computing makes it more difficult. Even for the software as a service (SaaS) provides the cost of developing multitenancy within their offering can be very substantial. Therefore, a strategic and viable charging model for SaaS provider is crucial for the profitability and sustainability of SaaS cloud providers.

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, Dec 2022

5. Conclusion

Due to the massive energy consumption of data centres and their harmful environmental impact, energy conservation is one of the difficult problems in the cloud. However, there are numerous hardware and software optimisation methods for green, energy-efficient cloud computing.

In order to reduce operating costs, optimise energy consumption, and ensure effective use of computing resources, this study addressed numerous strategies based on virtual machine migration and consolidation. Some of the current research on energy consumption using various methods has been reviewed, and other upcoming approaches in this direction include artificial intelligence, such as fuzzy logic, artificial neural networks for selection and placement of virtual machines, SDN (software defined network), the Hadoop framework, and machine learning methods to increase energy efficiency, improve quality of service, and decrease SLA violations. Other directions for the future include improving algorithms' failure tolerance and scalability.

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