Challenges and Approaches in Green Data Center

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Abstract:

Cloud computing is a fast evolving area of information and communication technologies (ICTs)that has created new environmental issues. Cloud computing technologies have a widerange ofapplications due to their scalability, dependability, and trustworthiness, as well as their abilityto deliver high performance at a low cost. The cloud computing revolution is altering modern networking, offering both economic and technological benefits as well as potential environmental benefits. These innovations have the potential to improve energy efficiency while simultaneously reducing carbon emissions and e-waste. These traits have thepotential tomake cloud computing more environmentally friendly. Green cloud computing is the science and practise of properly designing, manufacturing, using, and disposing of computers, servers,and associated subsystems like displays, printers, storage devices, and networking and communication systems while minimising or eliminating environmental impact. The most significant reason for a data centre review is to understand capacity, dependability, durability,algorithmic efficiency, resource allocation, virtualization, power management, and other elements. The green cloud design aims to reduce data centre power consumption. The main advantage of green cloud computing architecture is that it ensures real-time performance whilereducing IDC's energy consumption (internet data center).This paper analyzed the difficultiesfaced by data centers such as capacity planning and management, up-time and performance maintenance, energy efficiency and cost cutting, real time monitoring and reporting. The solution for the identified problems with DCIM system is also presented in this paper. Finally, it discusses the market report's coverage of green data centres, green computing principles, andfuture research challenges. This comprehensive green cloud analysis study will assist native green research fellows in learning about green cloud concerns and understanding future research challenges in the field.

Keywords: green information and communication technologies, environmental protection, data center power consumption, challenges in data centers, DCIM system.

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1. Introduction:

Cloud computing is the supply of computing services such as servers, storage, databases,networking, software, analytics, and intelligence over the internet in order to enable quicker innovation, more flexible resources, and cost savings. You usually only pay for the cloud services you use, allowing you to save money, better manage your infrastructure, and scale your business as it develops. Companies choose to access their computing power through the internet, or the cloud, and pay for it as they use it, rather than investing extensively in databases,software, and hardware. Servers, storage, databases, networking, software, analytics, and business intelligence are all examples of cloud services today. Cloud computing gives organisations the speed, scalability, and flexibility they need to build, innovate, and maintain commercial IT systems. The service provider is in charge of everything (the consumer needs nothing but a personal computer and internet access). As a consequence of substantial developments in virtualization and distributed computing, as well as increased access to high-speed internet, cloud computing has gained in popularity. The cloud migration is shown in the Fig 1.

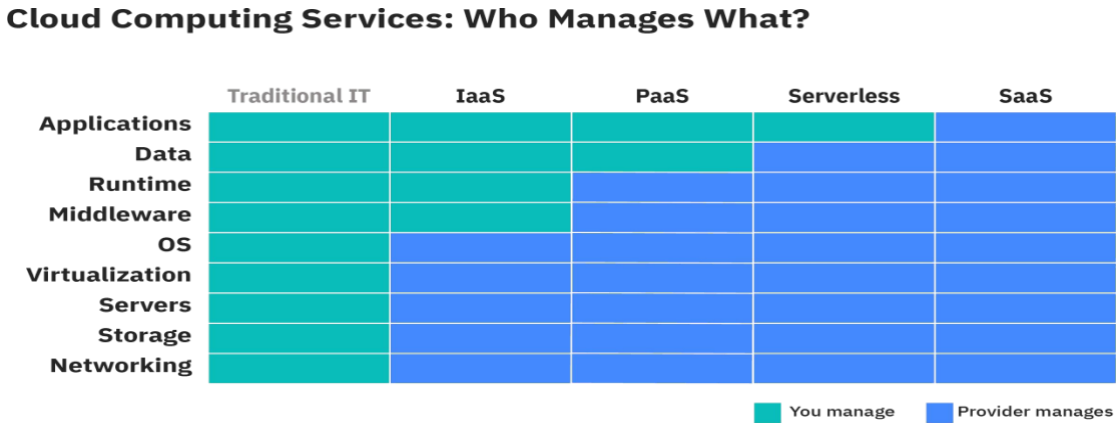

Fig. 1: Cloud for Companies – Cloud Migration

Data centers in cloud computing

A data centre is a physical place where a business's mission-critical applications and dataare stored. A data center's design is based on a network of computer and storage resources thatenables for the delivery of shared programmes and data[1]. This frees up resources for enterprise cloud customers to focus on their main business. Customers often have shared accessto virtualized computing resources such as virtual machines from the cloud provider, as well as dedicated access to specific actual computers, storage, and networking infrastructure.Government organisations, educational institutions, telecommunications firms, and financial institutions are all examples of this type of organisation.

Institutions, retailers of all types, and suppliers of online information and social networkingservices like Google and Facebook all require data centres in some fashion[1].

The Indian public cloud services industry was valued over a billion dollars in 2016, and itis expected to increase to more than four billion dollars by 2020. Cloud computing is used in a public cloud to make resources available to consumers. Virtual machines, software, and storageare among the options available. The services might be offered for free or as part of a monthly subscription. Due to the limited number of users, corporate clouds provide improved security. The use of a public cloud has the advantage of allowing services to be accessible digitally via linked devices. Data on cloud services may be quickly retrieved in the case of a device or data loss, and it is often regarded safe from cyber-attacks and dangers. Figure 2 depicts therapid expansion of cloud computing.

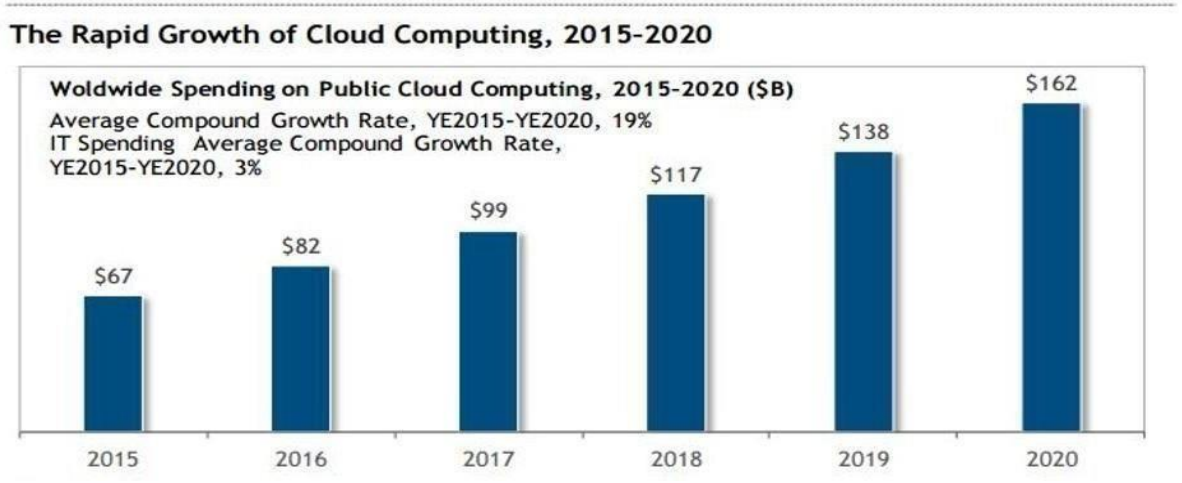

Fig. 2: Rapid growth of Cloud Computing

Green cloud computing

Green cloud computing refers to the process of designing, producing, and utilising digitalenvironments in an ecologically responsible manner. Businesses may save energy and money by implementing a green cloud solution [2]. Green cloud computing enables users to benefit from the advantages of cloud storage while decreasing negative environmental consequences,which have an influence on human health [2]. It includes the following practices:

Green design: The energy-efficient cloud infrastructure architecture includes services, computers, software applications, and other equipment that use less energy than their counterparts.

Green production: During recycling trips, the cloud infrastructure produces less garbage, leading in a more environmental conservation.

Green usage: When employing a cloud-based solution, it decreases the amount of energyproduced by 27 percent.

Green data centers

For certain data centres, the necessary adjustments to ensure their long-term viability are excessively expensive and difficult. Options for deploying technologies such as a new coolingsystem are limited due to logistical, budgetary, and operational constraints. There are nevertheless, many reasons to be optimistic. Many businesses are coming up with innovative solutions to the problem. For example, there is increased interest in situating facilities in cold climates to allow for free air cooling – or even under water to take use of naturally cold and flowing water [3].

However, due to a mix of realistic management constraints and the growing tendency toward edge computing, these options only give apportion of the solution. As a result, it's vitalthat sustainability is included in the construction of all new facilities, hyper scale data centres,and large-scale data centres, such as multi-data centre campuses across Europe. Increase the number of green data centres in the global data centre to reduce the carbon foot print if we worktogether [3].

Green cloud computing: altering your data centers!

The Cloud system to the heart of the cosmos, which continuously rehydrates the earth,much as our technological cloud does. Green cloud computing creates an earth that is inhabitable and exquisite in its own right, as seen in Fig 3. It also gives a preview of environmentally friendly, energy efficient processes in one spot. [4]Green cloud computing provides improved energy efficiency, managed security services, and cloud security solutions all in one place, as well as similar and cloud management platform benefits with a significant

environmental impact! Cloud computing is an important part of any company's IT operations,and there are constant initiatives to make it more "green". Organizations use "the green cloud,"a superior marketing term, to successfully handle environmental issues and concerns. Green cloud is the most environmentally friendly efforts in contributes to important company operational goals and reduces expenses across servers [5].

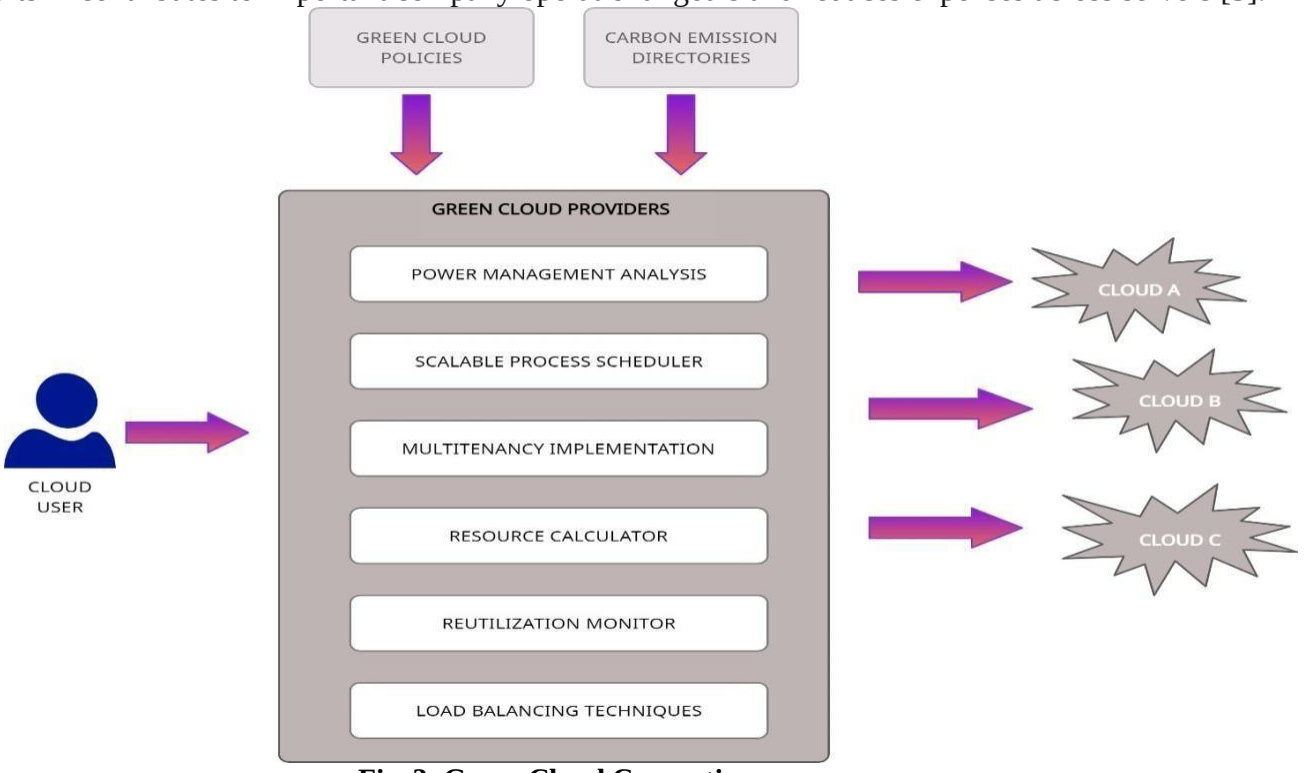

Fig. 3: Green Cloud Computing.

2. Literature Survey

Although small and medium businesses rely on third-party data centre services, practicallyevery medium to large business has its own data centre. Owning a data centre is a considerableexpenditure for organisations because to the high initial investment, resource needs (ITresources, power, and human resources), poor second-hand value of the equipment, and rapiddevelopments in IT technology that necessitate new equipment acquisition. In traditional datacentres, the energy efficiency of IT devices and infrastructure equipment is rarely stressed. Forgreen data centres, key performance indicators (KPIs) include the SLA and, most importantly,the data center's overall energy use [6]. As a result, the advantages ofa green data centreinclude extended equipment life-time, cheaper maintenance expenses, environmentalconservation, minimized electrical grid burden, and so on. These effects do not necessitate athorough or intensive implementation of green initiatives; even basic and low- cost effortsperformed early in the design phase could result in a 20% to 50% reduction in electricity costs.The service level agreement (SLA) between data centre managers and an entrepreneur is inextricably tied to data centre expansion. According to the SLA, data centre owners must expand and maintain their facilities and services to meet the needs of their clients. On the otherhand, business owners must adapt their strategies to the market and the needs of their customers. [7].

To meet increasing market demands, more apps must be developed and more data must be saved. Data centre productivity is determined by performance, which has an impact on the service level agreement (SLA) with clients. IT equipment and data centre infrastructure performance Data centre productivity is determined by performance, which has an impact on the service level agreement (SLA) with clients. The performance of

IT equipment and data centre infrastructure is crucial in data centre architecture and governance [8]. However, conventional wisdom holds that data centre productivity is inversely proportional to energy efficiency. To put it another way, data centre stakeholders must sacrifice productivity in orderto be green. Since Meisner and Wenish established that high-power servers are typically moreenergy efficient than reduced servers [9], that's not always the case.

In the context of big data, data center owners encounter difficulties such as high performance computing (HPC) and parallel computing. Both big data and HPC require massiveprocessing power, necessitating the usage of massive servers, storage, and connectivity, amongother things. These large requirements could not be avoided in today's rapidly expanding globe,and they will surely increase data centre energy consumption. However, one strategy to mitigate the damage is to increase processing efficiency such that every watt of power used creates equivalent or more value.

Data centre owners face issues such as high performance computing (HPC) and parallel computing in conjunction to big data. Both big data and HPC demand exceedingly huge processing capabilities, necessitating the use of gigantic servers, storage, and connection, among other things. These large requirements could not be avoided in today's rapidly expanding globe, and they will surely increase data centre energy consumption. However, onestrategy to mitigate the damage is to increase processing efficiency such that every watt of power used creates equivalent or more value.

The values and position of society have an impact on people's attitudes and mentalities. Lack of community exposure or an uncomfortable scenario can lead to popular ignorance. To avoid ignorance and create a conservation society, energy efficiency knowledge should be developed from the beginning of a person's life. People should be taught to conserve energy whenever, wherever, and whenever possible [10]. This includes turning off lights. People's belief in the "buy more, pay less" philosophy is another element that contributes to energy waste. We've grown so accustomed to paying less for more at the grocery that we've unknowingly applied it to our power usage [11]. We've become so accustomed to obtaining more for less money at the shop that we unconsciously apply the same mentality to our energyusage.

1. Challenges and Approaches in Data Center

Challenge 1:

Data centres have so much going on within, errors are certain to occur. At the same time, thereare applications, connecting cables, network connectivity, cooling systems, power distribution,storage units, and much more. Operators and managers of data centres must continually monitor and report on a variety of indications.

Solution

A data centre management system (DCIM) gives you more information about your data center's operations and performance indicators. It enables you to track, analyse, and generate reports in real time, allowing you to make informed decisions and respond promptly. Real- time monitoring and centralization of power usage in data centres is required, and data can be presented on an HMI and uploaded to a power and environment monitoring system via RS485 on a touch screen to achieve real-time monitoring of the entire power distribution system. Simultaneously, it may do an energy efficiency analysis in order to cut down on energy consumption. Figure 5 depicts the Data Center Energy Management monitoring system.

Challenge 2:

Data Centre managers are prone to over-provisioning in order to avoid downtime. There is a waste of resources and space as a result of this. In addition, there is a waste of power and energy. The capacity of a Data Center has always been an unresolved topic for Data Center management as the amount of data has grown, but only until a solution for Data Center infrastructure management was devised [12].

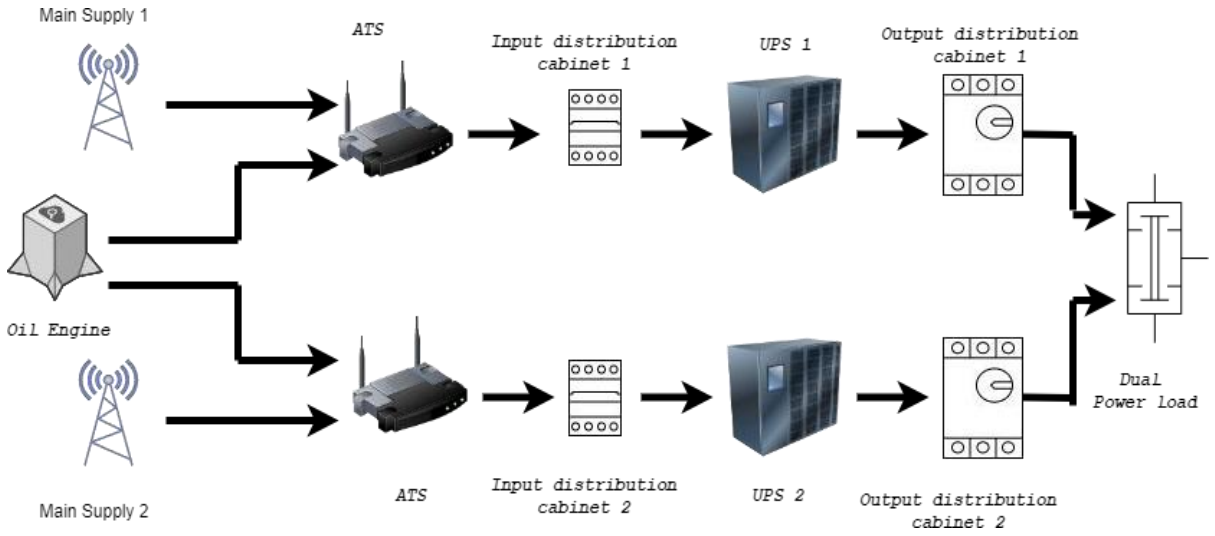

Fig. 5: Monitoring system for Data Centre Energy Management

Solution

A DCIM system can be used by data centre administrators to find unused physical space,capacity, electricity, cooling, and other resources in a data centre. This makes increasing capacity simple while reducing costs, preserving energy, and eliminating downtime. Data centre capacity planning is the creation of a strategy that ensures an IT organization's computing resources, powerload, footprint, and cooling capacity are sufficient to meet the workload requirements of its users and clients. The process of calculating an organization's production capacity in order to meet changing product demand is known as capacity planning.The process of calculating how much storage, computer hardware, software, and network infrastructure will be required is known as IT capacity planning. Capacity planning and management are depicted in Figure 6.

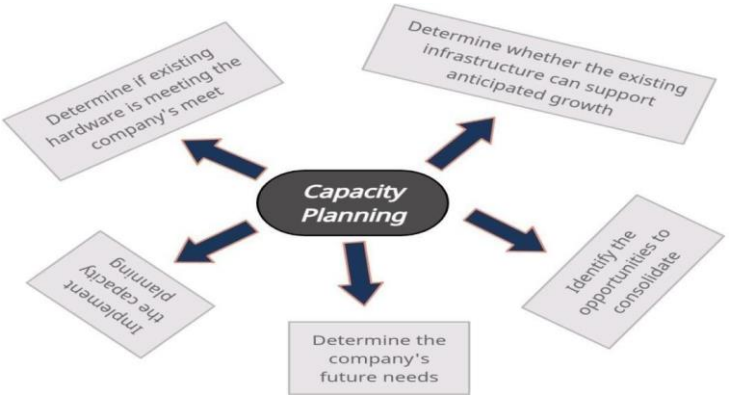

Fig. 6: Capacity Planning and Management

Challenge 3:

Data centre managers and operators are most concerned with measuring performance and guaranteeing data centre uptime. This also entails maintaining power and cooling precision, as well as assuring the overall structure's energy efficiency. In most circumstances, manuallycomputing the metrics is of no or little use.

Solution

A sophisticated solution like a DCIM system (Data Centre Infrastructure Management) may help you examine crucial characteristics like Power Usage Effectiveness (PUE) in real- time, making it easier to

optimise and monitor uptime and other performance indicators. Tier 4, or 99.995 percent availability, is considered the highest level of availability.

Under no circumstances may uptime go below tier 1, which is 99.671% availability. It might be tough to keep up to date with fast speeds and good uptime while employing an old orunreliable IT infrastructure. System failure is usually caused by insufficient monitoring tools. When you use a well-managed data centre. By continually improving the system with regular maintenance, it may prevent unexpected downtime and boost uptime. Data centre uptime maybe improved by detailed design, adequate system maintenance, and effective administration. and is shown in Fig 7.

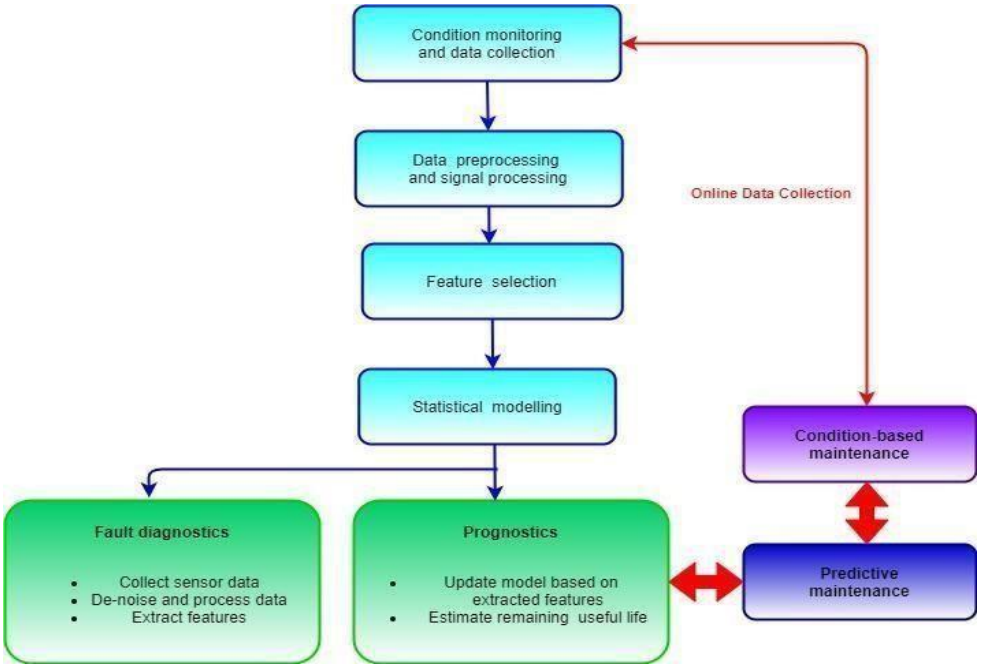

Fig. 7: Maintenance for Data Center Operation Management

Challenge 4:

The data centre industry is constantly in trouble due to its high energy usage and escalating temperature problem. A data centre facility can sometimes waste more energy than it uses. When there are insufficient energy monitoring tools and environmental sensors, this occurs.

Solution

You may use a DCIM system to efficiently monitor energy consumption, make changes, and save money when it's possible. This will assist to down data centre costs while also beingenvironmentally friendly and energy efficient. Workloads should be decluttered, and unnecessary equipment should be eliminated. Consolidate virtual machines to virtualize extra workloads. Replace inefficient or old technology with newer, more efficient equipment. If yourcooling system is over 10 years old, you should replace it to improve efficiency.

According to users and analysts, storage consolidation, server virtualization, data centre consolidation, thin-client computing, open source, IP telephony, and autonomous computing can reduce overall operational costs by 25 to 90 percent with smart implementation of these seven new data centre technologies. Fig 8 shows energy used in data center.

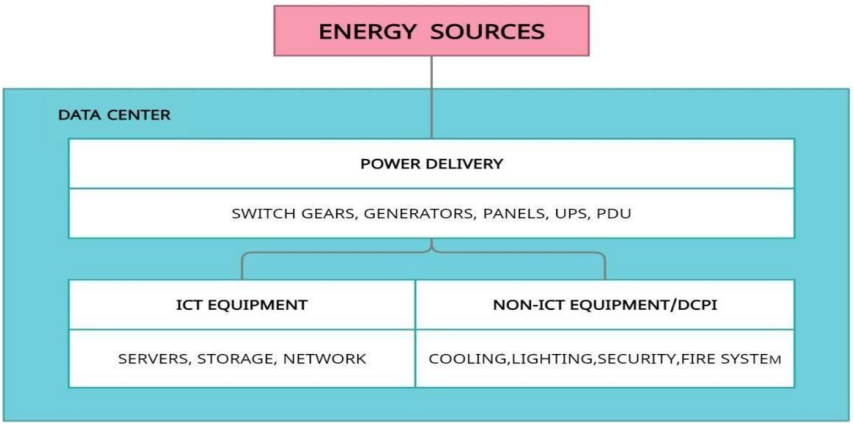

Fig. 8: Energy used in Data Center

Table 1: Challenges and approaches in data centre

Sr No	Challenges	Solution
01	Real time monitoring and Reporting	Allows for real-time tracking, analysis, and report generation, allowing for well-informed judgments and quick action.
02	Capacity Planning and Management	Determining the capacity of an organization's production in order tomeet changing product demand
03	Uptime and Performance Maintenance	Measure critical indicators in real time, such as Power Usage Effectiveness (PUE), to make iteasierto improve and control uptime and other outcomes.
04	Energy Efficiency and Cost Cutting	Clean up your workloads and get ridof any unnecessary equipment. Replace inefficient or old technologywith newer, more efficient equipment.

3. Green data center market report coverage:

Green cloud future challenges:

Cloud computing has a great deal of promise. The report coverage of the Green Data Centre isshown in Table 2. India's cloud computing business is worth $2 billion, according to a research,and is predicted to increase at a 30% annual pace. India's cloud computing sector is expected to be worth $4 billion by 2020, employing over a million people.

Table 2: Report Coverage of Green Data Centre

Report coverage	***Details***
Base area	*2021*
Market size in 2020	*53.19 Billion (USD)*
Forecast period	*2021 -2026*
Forecast period:2021- 2026CAGR	*23.01%*
2026 Value projection	*181.91Billion (USD)*
Growth drivers	The demand for storage is obviously driving data centre industry expansion, with more hyperscale facilities capable of storing hugequantities of data being developed across the world
Pitfalls & Challenges	Equipment is more expensive than older technologies. In a data centre, uptime and performance must be maintained.Green storage systems have security concerns. Green solutions are incompatible with existing data centres.

In this industry, cloud infrastructure engineers, cloud architects, cloud enterprise architects, and cloud software engineers are all in high demand [13]. It's clear to see how brightthe future for cloud computing professionals appears with such a high rate of predicted development. Furthermore, rising power costs throughout the world are giving the industry plenty of chances· For their operations, data centres require non-renewable energy sources to be transformed into electrical energy. Coal, fossil fuels, and other non-renewable energy sources are used to power electricity generators [13].

Future Scope in India:

Fig. 9: Global Green Data Centre Market (2012 – 2022).

As shown in Figure 9, the starting salary for an entry-level position in the cloud computing business is 5 lakh per year and rises to 7 lakh per year. Gaining the ability to earn more moneyby becoming a cloud computing expert. Senior cloud experts with more than 15 years of experience can earn more than a crore per year, while mid-level managers might make up to 20 lakh per year. There is a tremendous paucity of skill in this profession as well. [14] According to the same study, there are over 1.7 million cloud job opportunities globally owing to a scarcity of qualified people. Only around 1% of applicants have the necessary qualifications to work as a cloud specialist. To achieve optimum efficiency, analysecurrent data centre power and cooling designs, server power consumption, and cooling requirements. Modeling tools to estimate the energy usage of all cloud components and servicesare also essential for allowing green cloud data centres. Consider factors such as the number ofservers, each kind of switch, the number of users, and total connectivity in a data centre whenbuilding holistic solutions to reduce overall data centre power consumption. Our primary goalwill be to increase the efficiency of cloud computing equipment.

4. Conclusion

This study presented a literature evaluation on green cloud computing as part of our research analysis on green cloud computing. At first sight, the concept of cloud computing and the necessity to build green clouds were briefly discussed. Former researchers studied green cloudsand discovered constraints as well as remedies for a better understanding of the situation. Theirfindings revealed limitations and suggested solutions, allowing them to comprehend theimportance of green computing and collaborate for a healthier and greener environment for future generations. During the Design phase, DCIM provides crucial information for designing the correct infrastructure. Power, cooling, and network information help determine the ideal position for new servers at the rack level. DCIM could also provide IT data, such as server resources. Using green computing approaches, developers may produce an ecologically friendlyenvironment as well as other benefits such as cost reduction, energy savings, and waste minimization. The authors of this study have put together a quick reference guide for green cloud researchers who want to learn about the benefits of green cloud computing,

current trends, and future research difficulties.

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Conflict of interest: The authors state that they have no known financial or personal conflicts of interest that may haveimpacted the study's conclusions.

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