Research on Energy Efficiency in Cloud Computing

Nazmul Hossain, Md. Alam Hossain, A. K. M. Fayezul Islam, Priyanka Banarjee, Tahira Yasmin

Abstract— Cloud computing is a highly adaptable and efficient infrastructure for running endeavor and web applications. Energy consumption expenditure and concurrent effects on environment are the dynamic challenges regarding to cloud computing. We investigated previous researches based on energy efficiency approaches and retrieved the conditions to promote green cloud computing architectures. Data centers are considered as the backbone of cloud infrastructure. Numerous companies are investing in establishing large data centers to accommodate different cloud computing services. These data centers absorb huge amount of energy. They are also very complex in the infrastructure. Over the years, power consumption has emerged as an important factor for measuring computing resources expenditure. In this paper we will scrutinize all feasible spheres in an ideal cloud infrastructure which are responsible for massive amount of energy consumption. Here, we will also analyze the methodologies by which energy utilization can be reduced without compromising Quality of Services and overall performance. In order to make these data centers more energy efficient, many studies have been proposed. These researches are based on technologies such as consolidation and virtualization. Reducing emissions of carbon dioxide and energy consumption set up new challenges. The research works for green data centers are derived from the challenges. There is a current demand of integrated energy efficient cloud framework for establishing data centers that minimizes the impacts on environment and lessens CO2 emissions. The framework should combine a green IT architecture with different procedures and activities.

Index Terms— Cloud, Green IT, efficiency, cluster, server, data centers, virtualization, PUE metric, GAF, CEC, ASCENT, LEACH.

1 Introduction

This paper analyzes the energy efficiency of cloud computing. Since cloud computing is considered as an auspicious technology, it can offer many benefits. Saving energy has now a primary preference in almost all sectors of the IT business. Both corporate users and individual end users are being offered these new services. Services of these types are generally called cloud computing services .The cloud computing service model comprises of high-capacity storage devices and computing resources that are shared among corporate and individual users by a service provider.

Nowadays energy efficiency is a thoroughly argued and mostly researched topic in IT sectors. The expanding financial stress to reduce energy relevant expenditures combined with the strategy and regulative measures about CO2 emissions are prompting the arrangement and consumption of IT services faster than ever. Nowadays Green computing is emerging as a critical issue for IT related organizations. Organizations want to be more feasible and liable to offer their resources to the governments, customers and to the organization itself. Green computing along with green technology is scrutinizing the environmental friendly use of computers and related resources. Cloud Computing services are provided by large data centers composed of numerous virtualized server instances, high- bandwidth networks, as well as supporting systems such as cooling and power supply. The equipment can be formed with hardware and software. Cloud services are accessed by users through network equipment that connects servers to the Internet both part of the hardware equipment and software. User's software runs on top of servers and is handled by Cloud Management System.

Cloud computing basically offers a comprehensive commercial benefit, where users (corporate and others) share centrally managed storage devices and other computing resources. The users do not need to control and operate their owned systems. Since data centers are used as a basis, involvement of cloud service providers is in the management of storage devices and other computing resources. So, major part of their investment is in the necessary infrastructure and management. Energy efficiency can be defined as a reduction of energy for a given service or level of activity. However, we know about the range and complexity of data center equipment. Therefore, it is hard to define unique service or activity which could be used to measure its energy efficiency.

2 Overview of Cloud Computing

Cloud computing is generally an internet-based wireless computing. Remote servers are connected together to share high-capacity storage devices and computing resources. It acquiesces sharing of data-processing tasks among users by a service provider. The combination of computing resources is managed by various third-party providers. They provide access to highly efficient computing networks and advanced software applications. They also describe a variety of cloud computing concepts. They rely on sharing computing resources among users and comprise a large number of computers where the computers are linked together by a communication network. Cloud Computing is also labeled as "a network-oriented computing" [1]. In cloud computing, applications or programs have their ability to perform on several shared computers at a time. The term "cloud computing" is correlative to distributed computing over a communication network.

2.1 Characteristics

There are some important characteristics related to Cloud computing. It preserves technical issues from the environmental and economic perspective. These characteristics are supposed to be the main requirements of the IT industry for future improvement. The main characteristics are: Centralization, service oriented, virtualization, economy of scale, elasticity, dynamicity, Market-Oriented, autonomic, Standardization and Multi-tenancy [2]:

1) Centralization: Centralization means shifting all computing resources which are used for storage, infrastructure and applications to the Cloud. So that, we can reduce cost and also can have an improved resource management system.

2) Service-Oriented: We know, everything in the cloud means a service. Software, infrastructures, storage and platform are allowed as cloud services that made accessible through the network. To achieve this, cloud is executed by Service-Oriented Architecture (SOA) model. Moreover, SOA is normally used as an architectural pattern. It is closely coupled, allows composition. It is used for building cloud application, So, Cloud models can be benefited from this architecture in constructing any of its services i.e. storage, infrastructure etc.

3) Virtualization: The virtualization is accomplished at platform level. Cloud resources i.e. storage, computing and networking are virtualized at virtual machine levels. In the platform level, every application is generalized to one or more resources provided by different cloud infrastructure providers. Applications can run within their operating systems on the same physical machine. They can also easily be shifted from one physical server to another.

4) Economy of Scale: Oftentimes cloud computing is described as a technology. But, it is literally an important transformation in the business and economic models for consuming IT infrastructure that can accelerate a significant cost saving. The capability of cost saving by resource pooling makes the resource to be shared among the users. Resources can also be dynamically allocated according to the applications demand. Cloud computing is also an architectural model which is designed with multi-tenant applications. So in a cloud computing model the users have no control over the physical resources. They are also not aware about the resource location.

5) Elasticity: Cloud provides the flexibility, dynamically provision and varies the resources designated for its applications. The resources (storage, computing, and network capacity etc.) will increase or decrease at runtime depending on the user QoS requirements.

6) Dynamicity: It moves virtual storage and machines occupied by the data center. It also helps them to run due to more suitable conditions such as daytime, power consumption, maintenance concerns and lower cost. Just as the resources are also dynamic, they can be changed (increased or decreased) depending on the user requirements.

7) Market-Oriented: This characteristic dispatches the utility cost dimension of cloud computing. The billing system of cloud computing is likely a utility. So the smallest businesses can also afford it for their purposes. The users have to pay only for the services that they are using.

8) Autonomic: Cloud services are considered as highly reliable. They are also autonomic. The autonomic behavior is shown by managing themselves in case of the performance deprivation or failures.

9) Standardization: Standardization has immense impact on cloud adoption and usage. In order to exclude the complexity from Cloud, all the operating systems belong to one company should be used inside Cloud or one vendor equipment's like vendor routers and switches should be shared among other vendors. Thus it will witness high amount of energy and gain thrust from different users, vendors and standard bodies.

10) Multi-tenancy: Multi-tenancy is one of the key characteristic of both public and private clouds. A tenant is known as an application. Each tenant needs its own privileged virtual computing environment. In a typical multi tenancy structure, multiple users do not share each other's data. But they use the shared infrastructure. Resources are allocated to users in need. They do not have to concern of location of services and other users they shared with.

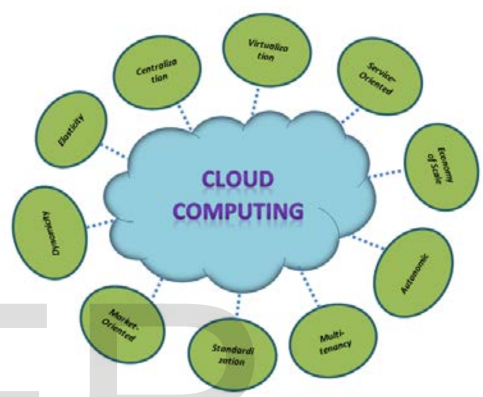

Fig. 1. Cloud Computing Characteristics.

2.2 Cloud Service Models

Cloud computing providers provide their services in accordance with three elementary models. It is generally an assortment of these models/layers to construct the computing structure of the cloud system. Each of them provides different types of services to the end user. The layers named Infrastructure as a service (IaaS), Platform as a service (PaaS) correspondingly Software as a service (SaaS). Their characterization besides their offered services is described below [2]:

1) Software as a Service (SaaS): SaaS is a software sharing model. In SaaS, a service provider or vendor manages the applications. They make the applications available to the customers through a network, generally via the Internet. SaaS is enhancing as an increasingly ubiquitous delivery model. It appears as an underlying technology that supports service-oriented architecture (SOA) as well as web services. Through the help of SaaS, mature and new instructive approaches are gaining popularity day by day. SaaS is also usually correlated with a pay-as-you-go agreement and authorization model. Meanwhile, broadband services have become instantly available to provide the user access from more areas around the world [3].

SaaS applications must also interact with other data and applications in a symmetrically extended range of platforms and environments. These applications are also proximately associated to other service models that we have illustrated.

ISSN 2229-5518

There are two imperceptibly different SaaS delivery models identified by IDC. It is accepted as a prevalent delivery model in different business enterprises for their business applications including small to large businesses that encompasses Manufacturing Resources Planning (MRPII), Customer relationship management (CRM), Human resource management (HRM), Enterprise resource planning (ERP) along with numerous other business related applications and platforms [4].

Example: NetSuite, Salesforce.com, Workday, Concur etc.

2) Platform-as-a-Service (PaaS): Platforms are included in cloud computing for building and successfully executing custom web-based applications. Platform-as-a-Service is a concept known for these services. It provides the users with ideal development environment to assist the development lifecycle beginning from the steps: designing, implementation, debugging, testing, deployment. It also supports the operations of rich internet application (RIA), a solution stack as a service and online services. The PaaS model helps to make all the facilities available required assisting the life cycle of developing and delivering various web applications and services wholly convenient from the Internet. But it does not require downloading and installing of any software. Therefore, it is greatly helpful for the developers, IT officials, or end users. It is called the prolongation of the SaaS application delivery model [5].

Example: Google application engine, Aneka, 3Tera, Coghead, Microsoft Azure etc.

3) Infrastructure-as-a-Service (IaaS): IaaS administrates virtualized computing resources through the Internet. Infrastructure as a Service is a software provision model. In IaaS, an organization redistributes the appliances used to support various networking operations. It includes different hardware equipment, servers, storage devices and networking appliances. The appliances are controlled by the service provider. And housing, running and maintaining the appliances is the responsibility of the service provider. It consists of physical or virtual machines, storage and clusters. IAAS layer also comprises DBMS systems and other storage relevant services [6]. The infrastructure of IaaS is handled by an upward management layer. It also maintains the runtime environment customization, accounting, application isolation, and QoS services [7]. IaaS virtually leverages the SaaS model that helps to solve the identity problem. It also provides for single sign-on for web applications, strong authentication process and federation across boundaries [8].

Example: Amazon AWS, Mosso, Joyent etc.

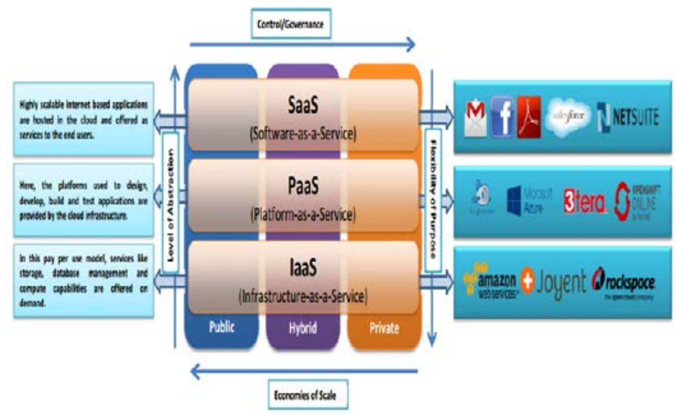

Fig. 2. Cloud Service Models.

2.3 Cloud Deployment Models

Cloud computing is an archetype that offers different services in on-demand delivery model [9]. As stated in the previously specified services and computing characteristics, cloud deployment models are classified into four types to work in consistency with other elements. They are- Public cloud, Private Cloud, Hybrid Cloud and Community Cloud [10].

1) Public cloud: Public cloud is one of the cloud models that make the services, such as storage and applications available for general use through the Internet. Here, the computing infrastructure is governed by cloud vendors. The customer has no physical visibility as well as control over the site where the whole infrastructure is hosted and maintained. The infrastructures are shared among different organizations. Service providers host the cloud infrastructure. They made the public clouds accessible for the general use to the public [11]. Usually, public cloud service providers such as Google, Microsoft, HP, IBM, Salesforce, Amazon Web Services (AWS) etc. possess and operate the infrastructures. They offer access of their services over the Internet. Public Cloud is beneficial. Customers will benefit from this model in economies of scale. Because in public cloud, infrastructure costs is shared among all users. Each singular client is allowed to work on a minimal-cost, "pay-as-you-go" paradigm. Public clouds are ordinarily larger than an in-house enterprise cloud in scale. This provides clients with consistent, on-demand scalability.

2) Private Cloud: Private cloud is another cloud infrastructure model that is dedicated to an individual organization. Private clouds permit organizations to host their applications. Public cloud infrastructure is lacked of control and data security. But private cloud concentrates concerns about data security and control. For security, it is unshared with other organizations. Generally, public cloud is also controlled internally or externally by a third-party [12].

3) Community Cloud: Community cloud is considered as a multi-tenant cloud model. Here the cloud components are shared among particular organizations. Community cloud is managed, governed and secured generally by all the associating organizations or a third party provider. Community cloud

- *Nazmul Hossain is currently serving as Lecturer in Computer Science and engineering Department in Jessore University of Science & Technology, Bangladesh, PH-042172058. E-mail: nazmul.justcse@gmail.com*
- *Md. Alam Hossain is currently serving as Chairman in Computer Science and engineering Department in Jessore University of Science & Technology, Bangladesh, E-mail: alamcse_iu@yahoo.com*
- *Others are currently pursuing B. Sc. And M.Sc. degree program in Computer Science and engineering in Jessore University of Science & Technology, Bangladesh*

ISSN 2229-5518

concerns about sharing of inner parts of computing infrastructure in between organizations which are systematized in the same community. For example all IT organizations within the same state can share the computing resources on the community cloud to manage data. Community clouds are typically hybrid forms of private clouds that are specifically designed and managed for a targeted group of users. For this reason, communities should have identical list of cloud prerequisites. Their ultimate objective is to work together to acquire their business objectives [13].

The purpose of community clouds is to understand the benefits of a public cloud among participating organizations with extra level of security, privacy and policy acquiescence. So that they can differentiate between the securities usually affiliated with private cloud. These clouds can be on-premise otherwise off-premise.

4) Hybrid Cloud: A formation of two or more clouds which can be public, private or community but remain particular entities is called hybrid cloud. These entities are restrained together so that they can offer the adjustment of multiple deployment models. The architectural method of hybrid cloud can host crucial applications controlled by private clouds. But the applications having comparatively limited security concerns which are controlled by the public cloud can also be hosted by hybrid cloud. Thus the management of both public and private clouds is termed as hybrid cloud. Both on-premise resources and off- premise server based cloud infrastructure is required for the architecture of hybrid cloud [14].

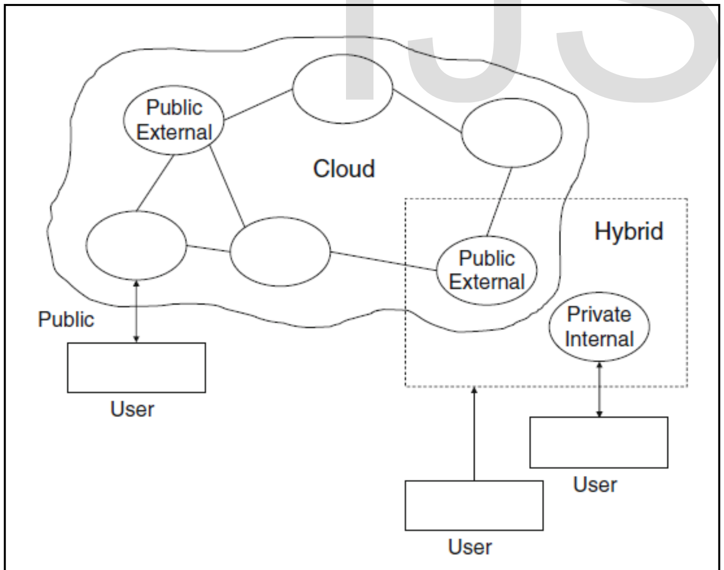

Fig. 3. Cloud Deployment Models.

2.4 Green Cloud Computing

The omnipresent agitation to acquire economical, ecological and environmental sustainability is arising to reorganize industrial perspective. The prevailing contingency of ecological deterioration, global warming and the harshness of its potential results clarify the overwhelming demand of environmental actions crosswise the world. In 2007, the EPA (Environmental Protection Agency) had proposed a statement to the US Congress which concerns about the conventional energy consumption techniques of data centers. Since then many governmental companies have started to develop regulations and standards that boost green computing. "Green IT" has being started to discuss by academia, media and government to describe about environmental impact on Information Technology (IT). Green cloud computing means the eco-friendly and environmentally reliable use of computers and other resources. So, Green Computing can be represented as environmentally imperishable computing. It generally addresses the effort/work to expand energy efficiency and power consumption. So that, we can minimizes the cost as well as CO_2 emission [15].

In broader terms, the study of designing, manufacturing, working and adapting computing resources in a way which will reduce environmental issues. IT manufacturers and providers are now increasingly investing in the development of energy efficient computing appliances. They also trying to reduce the use of critical materials and encourage the recyclability of resources. Green computing is renowned as Green information technology. The main objective of green computing is to scrutinize new computer systems and applications with low cost as well as CO2 emission and increase energy efficiency and lessen power consumption to boost the imperishable economic and social development. To make cloud greener, we have two ways. First we have to expand energy efficiency of cloud then supply clean energy. Green computing is also intent to gain economic sustainability and improve the computing devices usage policy [16].

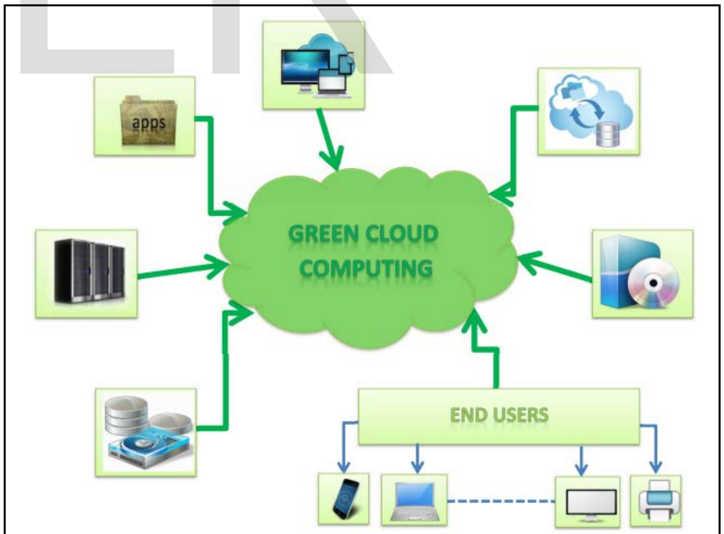

Fig. 4. Green Cloud Computing.

3 Overview of Energy Efficiency

The energy efficiency of an enormous computing infrastructure can be upgraded at different levels. But identifying the power consumed by the components is generally a challenging task, because it often needs instrumentation. However it is crucial to design and evaluate energy-efficient architectures and algorithms. At overall infrastructure level, such as in a grid or hybrid acknowledgments can be coordinated to implement energy efficient policies [17].

2.1 Energy Efficiency on Cloud Computing

Instrumentation of an energy efficient cloud infrastructure requires not only energy efficient host machines. Other elements of an entire cloud infrastructure also should be treated for energy aware appliances. In this part we will discuss the sections for establishing a typical cloud infrastructure which are responsible for reasonable amount of power dissipation [18].

1) Energy Efficient Hardware: The better way to minimize the power consumption at host side is the usage of energy efficient components at data center, server and virtual machine level. International standard organizations i.e. US Energy Star and European TCO Certification are rating energy efficient user products. This rating is necessary to estimate the environmental impact and carbon emission rate of computer components. Modern electronics equipment like SSD drives is designed which is better power efficient than normally used HDD drives. But still they are costly enough [19].

2) Energy Efficient Resource Scheduling: Generally, resource scheduling is the essential process for the establishment of cloud infrastructures. So the necessity of resource scheduling in a cloud is must. Several analyses have been done which describes regarding resource scheduling process in both virtual machines and computing grid systems. As we know every server consists of limited resources. In this case, requests/jobs are needed to be scheduled. Applications in cloud computing is regarded as business processes which includes a set of conceptual processes. To designate the cloud resources to their corresponding tasks, we need to first schedule all of the resources and their corresponding tasks. Till now several algorithms is been developed about resource scheduling which deals with availability and reliability of resources. Some task scheduling algorithms are also being developed. Some are being developed on the principle of operating system. Many characteristic including availability, power consumption, response time and reliability etc. are needed to be counted while designing resource schedulers [20].

3) Energy Efficient Clusters of Servers: CPU power dissipation is a major problem for energy efficient servers. Here, the CPUs absorb the power-driven energy and then this energy is dissipated by CPU switching devices operations and by the energy wasted for heating. In energy efficient servers, power dissipation is basically minimized by optimal CPU utilization. Howbeit other cluster components likely memory devices, storage segments, network peripherals etc. may also consume noticeable amount of power. Therefore a Virtual Machine may also use significant amount of power-driven energy. So, new approaches are designed that aims to reduce this power dissipation in a group at clusters of servers by considering system's throughput and latency [21].

4) Energy efficient Network Infrastructure in cloud: Researchers give importance in reducing energy consumption in computing elements likely storage, infrastructure, applications, computation etc. But we do not give as much importance in energy minimization of network infrastructure. Two types of networks are applied in a cloud infrastructure - wired and wireless network. A report was released by ICT energy where they examines the radio access network and estimates the energy consumed by the infrastructure. According to report, a large part of the entire energy is consumed by the infrastructure. Moreover the cost aroused for energy consumption is also proportionate with the total expenditure spent for network maintenance and operations and on personnel. Micro Sensor Architectures are now commonly used. It includes four basic components- power supply, digital processing, radio transceiver and sensing circuitry. In this structure, maximum energy is consumed by radio transceiver while data processing and sensing circuitry consume very negligible amount of energy. The sensor is always remains in one of the following four states –receive transmit, sleeping or idle. For energy minimization, sensors should be kept in sleeping state because all other states consume extensive amount of energy. GAF (Geographic Adaptive Fidelity) and CEC (Cluster Based Energy Conservation) and other Topology Control Protocols were also propagated for energy minimization in sensor networks as well as wireless computing networks. These protocols can identify extravagant nodes and has the ability to turn them off to conserve energy [22].

A survey on different techniques used in energy efficiency improvement of Cloud systems-

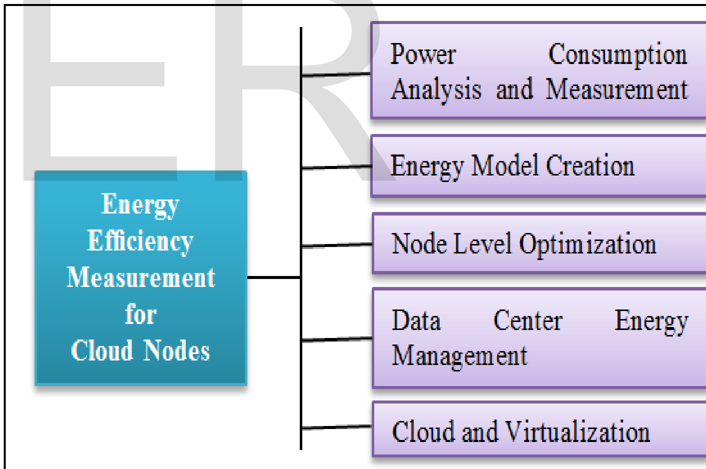

Fig. 5. Overview of techniques for improving the energy efficiency of Cloud Computing systems.

2.2 Data Centre Energy Efficiency

Data centers are considered as the biggest energy consumers in the cloud infrastructures. Data center consists several IT equipment, power systems, air conditioning scheme and energy resources. Energy consumed in a data center classified as site and IT infrastructure. Energy consumed by individual class is relatively equal to each other. Greater part of this energy is consumed for powering servers and energy resources respectively. They consume enormous amount of electrical energy of a Cloud. Therefore if we can decrease the energy used by data center even a small amount, we will accelerate an energy efficient and empirical Cloud computing [23].

To minimize the energy usage in a data center is now a hot issue in the IT industry. Improvement of an efficient data center doesn't imply rebuilding the infrastructure and the resources within it. Taking some simple steps in energy management can reduce the expenditures. A data center should be rationalized, virtualized and consolidated. We must review the temperature of the data center day-to-day. Water cooling method can be considered as an alternative. The volume of a data center should be considered. Renewable energy resources can be used and the energy distribution systems should be optimized [24, 25].

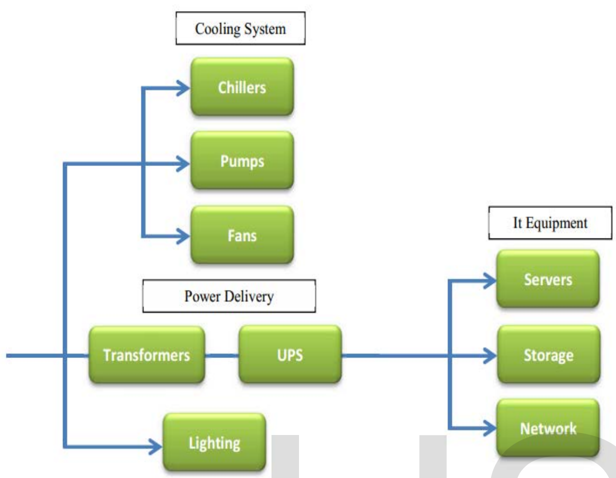

Fig. 6. Electrical components of data center.

2.3 Server Energy Efficiency

Though efficiency of servers is considered as a hot issue in modern IT infrastructure development but transparency and appliance of efficient server solutions seem to be still limited. Most of the IT organizations also proclaimed that energy efficiency is not still considered as a pertinent principle up to now. But, awareness regarding energy saving possibilities is actually low. The great news is that energy efficiency technology has been currently used in marketing policies. There was also the impression is that finally energy efficiency technology is now being revolutionized from marketing strategies to practical usage [26].

PUE metric is widely used to measure the efficiency of the server infrastructure including power distribution and energy resources. While PUE metric persist in being a pivotal opportunity for measuring efficiency progression in server infrastructure, the potential energy emission reduction rate from enhancing PUE will be smaller than the rate accomplished from using cleaner electricity or developing server utilization [27].

Off-premise coordination facilities can produce more efficient energy resources management. However, when the servers are operated at low utilization levels as well as they are also using dirty electricity; coordination is only imperceptibly more advantageous than an on-premise [28].

Modernizing server appliances to latest advanced models is an alternative way to minimize overall energy consumption. According to different analysis, computing efficiency is multiplying in every year. Changing or "superseding" outdated equipment with newest equipment will save massive energy by using the lower idle power consumption and higher efficiency of the newest equipment. However, performance levels of computing server are also needed to be increased. Without the performance level, we cannot recognize the assurance of using more efficient hardware.

2.4 Energy Efficiency Protocols

The energy efficiency is most important for cloud networks compared to any other networks. Generally, data transceiver requires largest energy than the energy required by data processing in a network [29]. Multiple routes are used to transmit the data. These routes can build up a communication between a node and the sink. In order to establish these routes, the paths composed of multiple nodes that consists maximum energy resources are selected. Data transmission and battery power are proportional to each other. Whenever large numbers of data are transmitted by the nodes, their battery power will also proportionately get decreased. In order to minimize the data size as well as increase the lifetime of battery, aggregation or data fusion techniques can be used. But to get more efficiency, we generally use energy-efficient protocols. The objective of energy-efficient protocols is to select those paths that are supposed to maximize the lifetime of network. GAF and CEC protocols are used to identify redundant nodes and help the users to turn off them to preserve energy. Other net energy efficiency protocols such as ASCENT and LEACH are also conferred in cloud environment.

1) Geographic Adaptive Fidelity Protocol: GAF is known as an energy provision protocol which is actually based on equivalent node location. In GAF supernumerary nodes are determined rely on their geographic locations. In order to balance the load, the frequency of a node is switched off periodically. Generally GPS and GAF devices are used to provide the location information in GAF appropriately. But it will fail in applications, if the information about geographic location is not available. For this reason equivalent node concept is used by GAF. For communication these nodes are worked as intermediate nodes because they are equal to each other in terms of their connectivity. In GAF the total network area is separated into some small virtual grids. So that the nodes situated in neighboring grids are operating in each other's transmission range. Thus in GAF any nodes of individual virtual grid can be used for routing and a grid can use multiple nodes when it needs to balance the energy usage for that grid. Using GAF we can save energy by keeping only one node working per grid and turning all other remaining sensor nodes off and keeping them inactive. The nodes are systematically rotated to remain operative in a grid operating life cycle. So that only one node will be active on per grid operating life cycle at a time [30].

In GAF protocol, the nodes are always switching among three consecutive states as follows. Initially a node stays in discovery state with turning its radio on and it can exchange messages with neighbor node. When an equivalent node performs routing, the other nodes either in active state or in discovery state can shift to the sleeping state [22].

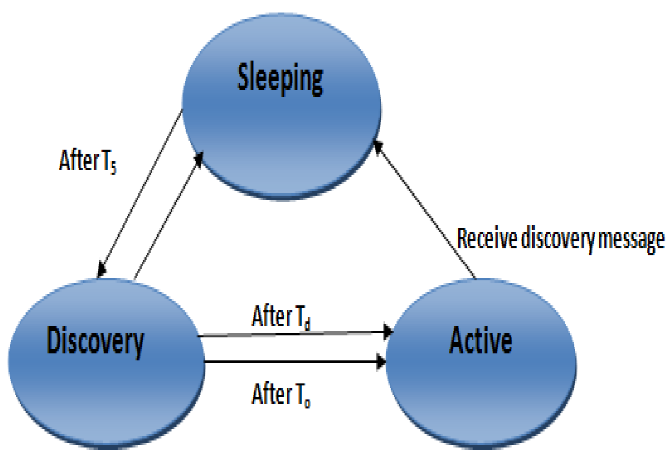

Fig. 7. State transition in GAF.

2) Cluster Based Energy Conservation Protocol: CEC protocol is used to measure and maintains the network connectivity immediately and instantly so that energy can be reserved by identifying the node to obtain a typical effective structure. The nodes are configured by CEC into super-imposed clusters. In CEC, each cluster includes cluster-head together with gateway nodes. Clustering is an important approach which is used to construct flexible sensor networks. The network is arranged into subsets of nodes by a clustering algorithm. In this network, individual cluster-head node is placed approximately at the center of the network. So, CEC represents the cluster as a collection of nodes. In CEC, cluster structure is formed in a distributed approach. Nodes are interconnected in cluster structure. As earlier said each cluster composes a cluster-head, components of the cluster network are in radio range of this node. Each node initially transmits an originating message which comprises the node ID together with cluster ID. To perform this operation, the cluster-head is selected first by CEC and then it identifies the gateway nodes through which the clusters are interconnected. When a node recognizes that it possesses the maximum energy amongst all the neighbor nodes, it acknowledges itself as a cluster-head and broadcasts this. Again if a node has the lengthy lifetime amongst its entire network neighbor nodes, it is selected as cluster-head. Similarly, for selecting the gateway from multiple gateways the gateway that possesses with lengthy lifetime is assigned the highest priority [31].

The main disadvantage faced with GAF protocol is that global location information is must needed. But we may not get the information always. With CEC protocol we have the ability to overcome this disadvantage. CEC does not need location information for transmission. It determines Network Redundancy and operates with Distributed Cluster structure steps [32].

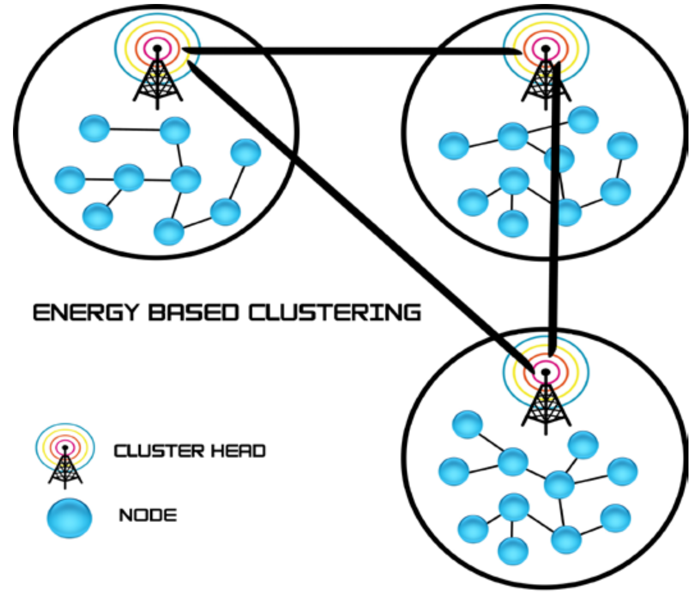

Fig. 8. Energy Aware Routing Protocol in Cluster based Wireless Sensor Networks.

3) Adaptive Self-Configuring sEnsor Networks Topology Protocol: ASCENT is considered as a data node selection protocol rather than a routing or data promulgation protocol. The main principle of ASCENT protocol is to simply determine the nodes that should be linked with the routing infrastructure. Data promulgation mechanisms like data dissemination or ad-hoc routing can run through this multi-hop topology. Hereof, routing protocols are considered as subsidiary to ASCENT. ASCENT protocol is formed of several phases. At first a node initializes itself and then moves into a hearkening-only phase. This phase recognized as neighbor discovery phase. Within this phase, individual node acquires an estimation of the number of neighboring nodes which actively transmitting messages through local partitions. ASCENT does not conduct with entire network. The network is split into several local partitions. We understand that enough node density is available to link the partitions and establish the entire region. At first, only a few nodes linked with this network. The other remain quietly and hearkening to the messages but they are not transmitting their messages. Data messages are started to transmit by the source toward the sink. The sink is placed at the range of radio transmission limit. During this phase, an individual node may join to the network transiently in attempt to contribute to upgrade the connectivity. But when a node wants to stay for a longer time, it moves into an active phase. Within this phase, it starts transmitting routing control messages as well as data messages. Furthermore when a node does not want to join the network, it moves into the adaptive phase. Within this phase, it turns off itself for a period of time. The following figure shows a simplified design for ASCENT during initialization [33].

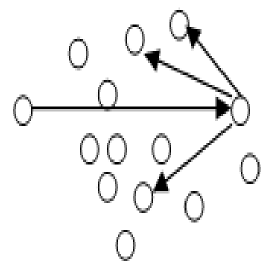

Fig. 9. Simplified schematic of a self-configurable sensor network.

4) Low-energy adaptive clustering hierarchy Protocol: Another clustering-based protocol is LEACH. In LEACH, localized cluster base stations are rotating randomly in order to uniformly distribute the energy load between the sensors within the network. Data aggregation strategy is used to reduce the volume of data to be relayed to the base station. The advantage of LEACH is that it can gain enough point in reduction of energy consumption in contrast with other conventional routing protocol. Conventional protocols regarding LEACH may be imperfect for static sensor networks. MTE, direct transmission, multi-hop routing etc. can be executed with LEACH [34]. As partitioning a network is time variable, all nodes in the network are supposed to be homogenous as well as positive energy-constrained. Network operations are split into several rounds. The first phase of each round is called a set-up step. In this phase, clusters are grouped by small transmitting distances. But phase decision is formed by the steady-state step independently at the same time. Data transferred to the base station by steady-state step is also compared to the setup phase operation. During advertisement step, every individual node decides itself whether it becomes a cluster-head or not [35].

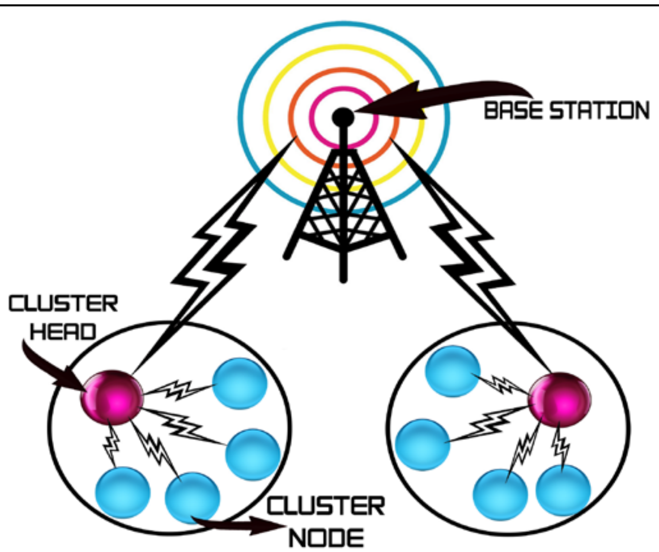

Fig. 10. LEACH protocol.

4 Conclusion

Cloud computing is expanding rapidly; demands for cloud implementation is increasing constantly. On the other hand, cloud providers are trying to host up additional servers to accommodate anticipated future server requirements. As more users are joining in cloud and sharing cloud services [36], significant changes will be made in economics and greater economic scale will be achieved. This will help the cloud providers to be able to make perfect prediction about cloud capacity for meeting the demand. Cloud computing has the advantages that it has enormous potentiality to revolutionize the IT sector by cutting down expenses, improving efficiency and developing business performance. Thus cloud computing can help us to achieve a better and a sustainable world. Within its capability, now cloud computing has the ability to reduce more than 90 percent carbon emissions for most important businesses. Future energy savings techniques are likely to evolve as cloud computing grows.

Here we discussed about energy efficiency at different cloud infrastructure and the ways to improve the energy efficiency of different computing and networking resources [37]. Because these resources are believed as the key components of various cloud systems. In view of computing resources, the techniques of energy efficient models are assigned at different architectural levels, including every single node to total infrastructures. The techniques are supported by recently advanced functionalities and components such as virtualization. Because of the analysis of different computing infrastructure, we judged that different energy efficient techniques and approaches should be applied. Some important features alike CPU utilization, QoS, reliability, performance etc. should be improved to achieve desired energy efficiency. Additionally, energy consumption reduction [38] and time complexity reduction should be made highly effective.

References

[1] P. Mell and T. Grance, "The nist definition of cloud computing (draft)," NIST special publication, vol. 800, no. 145, pp. 7, Jan. 2011.

[2] Ole J. Jacobsen, "A Quarterly Technical Publication for Internet and Intranet Professionals," The Internet Protocol, vol. 12, no. 3, pp. 6, Sep. 2009.

[3] R. Buyya, C. S. Yeo, and S. Venugopal, "Market-oriented cloud computing: Vision, hype, and reality for delivering IT services as computing utilities," *Proc. 10th IEEE Int. Conf. High Performance Computing Communication*, Dalian, China, pp. 5–13, Sep. 2008, doi:10.1109/HPCC.2008.172.

[4] Kay K. Kim, "The Impact of Operations Manufacturing Management Systems by Enterprise Resource Planning (ERP) Software Application," International Journal of Science and Engineering, vol. 2, no. 2, Feb. 2016.

[5] D. Beimborn, T. Miletzki, and S. Wenzel, "Platform as a Service (PaaS)," Business & Information Systems Engineering, vol. 3, no. 6, pp. 381–384, Dec. 2011.

[6] W. Voorsluys, R. Buyya, J. Broberg, M. Brock, and Andrzej Goscinski, "Cloud Computing: Principles and Paradigms," John Wiley & Sons, Inc, pp. 194-196, Mar. 2011.

[7] R. Moreno-Vozmediano, R. Montero, and I. Llorente, “IaaS cloud architecture: From virtualized datacenters to federated cloud infrastructures,” IEEE Computer Society, vol. 45, no. 12, pp. 65-72, Mar. 2011.

[8] W. Lloyd, S. Pallickara, O. David, J. Lyon, M. Arabi, and K. Rojas, “Performance implications of multi-tier application deployments on infrastructure-as-a-service clouds: Towards performance modeling,” Future Generation Computer Systems, vol. 29, no. 5, pp. 1254-1264, Jul. 2013.

[9] I. Buchmann, S. Frischbier, and D. Putz, “Towards an estimation model for software maintenance costs,” *Proc. 15th European Conference on Software Maintenance and Reengineering (CSMR)*, pp. 313–316, Mar. 2011, doi:10.1109/CSMR.2011.45.

[10] J. Keung and F. Kwok, “Cloud deployment model selection assessment for smes: Renting or buying a cloud,” *Proc. IEEE Fifth International Conference on Utility and Cloud Computing (UCC)*, pp. 21-28, Nov. 2012, doi:10.1109/UCC.2012.29.

[11] W. Jansen and T. Grance, “Guidelines on security and privacy in public cloud computing,” NIST special publication, pp. 800–144, Feb. 2011.

[12] X. Jing and Z. Jian-jin, “A Brief Survey on the Security Model of Cloud Computing,” *Proc. 9th International Conf. on Distributed Computing and Applications to Business Engineering and Science (DCABES)*, pp. 475 – 478, Aug. 2010, doi:10.1109/DCABES.2010.103.

[13] Dina V. Parmar, and Hemina C. Bhavsar, “Implementing Community Cloud to Overcome the Problems of Complexity and Security in Business Environment,” Indian Journal of Applied Research, vol. 4, no. 5, May 2014.

[14] J. Li, Y. Kit Li, X. Chen, Patrick P.C. Lee, and W. Lou, " A Hybrid Cloud Approach for Secure Authorized Deduplication," *IEEE Trans. Parallel and Distributed Systems*, vol. 26, no. 5, pp. 1206 - 1216, May 2015, doi:10.1109/TPDS.2014.2318320.

[15] A. Jain, M. Mishra, and S. Kumar Peddoju, “Energy Efficient Computing- Green Cloud Computing,” Indian Institute of Technology and Nitin Jain National Institute of Technology, pp. 978 - 982, Apr. 2013, doi:10.1109/ICEETS.2013.6533519.

[16] S. K. Garg and R. Buyya, “Green Cloud computing and Environmental Sustainability,” Cloud computing and Distributed Systems (CLOUDS) Laboratory, Department of Computer Science and Software Engineering, University of Melbourne, Australia, 2011.

[17] J. J. Green, “Computing Strategies for Improving Energy Efficiency in IT Systems,” International Journal of Scientific Engineering and Technology, vol. 3, no. 6, Jun 2014.

[18] T. Mastelic, and I. Brandic, “Recent Trends in Energy Efficient Cloud Computing,” Journal of LATEX CLASS FILES, vol. 11, no. 4, Dec 2012.

[19] U. Wajid, “Energy Efficient Systems, White Paper,” *Proc. IEEE SMC 2013 conference*, Manchester, UK, Nov. 2013.

[20] Q. Li, and Y. Guo, “Optimization of Resource Scheduling in Cloud Computing,” *Proc. 12th International Symposium on Symbolic and Numeric Algorithms for Scientific Computing*, pp. 315-320, Sep. 2010, doi:10.1109/SYNASC.2010.8.

[21] A. Beloglazov, R. Buyya, Y. Choon Lee, and A. Zomaya, “A Taxonomy and Survey of Energy-Efficient Data Centers and Cloud Computing Systems,” Technical Report, CLOUDS-TR-2010-3, Cloud Computing and Distributed Systems Laboratory, University of Melbourne, Australia, Jun. 2010.

[22] A. Banerjee, P. Agrawal and N. Ch. S. N. Iyengar, “Energy Efficiency Model for Cloud Computing,” International Journal of Energy, Information and Communications, Science & Engineering Research Support society, South Korea, vol. 4, no. 6, Dec. 2013.

[23] S. Strutt, C. Kelley, H. Singh and V. Smith, “Data Center Efficiency and IT Equipment Reliability at Wider Operating Temperature and Humidity Ranges,” White Paper, The Green Grid, USA, Feb. 2015.

[24] “Data Center Power: Managing for Energy Efficiency and Cost Savings,” White Paper STI-100-013, Quality Rack Power Solutions, Server Technology, USA, Nov. 2013.

[25] “Energy Logic: Reducing Data Center Energy Consumption by Creating Savings that Cascade Across Systems,” White Paper, Experts in Business-Critical Continuity, Server Technology, USA, Oct. 2010.

[26] M. Eastwood, J. C. Pucciarelli, J. S. Bozman and R. Perry, “The Business Value of Consolidating on Energy-Efficient Servers: Customer Findings,” White Paper, International Data Corporation, USA, May. 2009.

[27] J. Subramanian, “Going Beyond Power Usage Effectiveness (PUE) for Data Center Efficiency,” The Data Center Journal, Alpharetta, Georgia, May. 2012.

[28] J. Shuja , S. A. Madani , S. U. Khan , S. Sarwar, K. Bilal and K. Hayat, “Energy-efficient data centers,” Springer-Verlag GmbH Wien, Vienna, Austria, vol. 94, no. 12, pp 973-994, Dec. 2012.

[29] Nazmul Hossain and Md. Alam Hossain, “Integrated Cellular and Ad Hoc Relaying Systems: Analysis of Call Blocking Probability & Performance,” International Journal of Scientific & Engineering Research (IJSER), vol. 6, no. 12, pp 635-643, Dec. 2015.

[30] D. Virmani and S. Jain, “Clustering Based Topology Control Protocol for Data Delivery in Wireless Sensor Networks,” Networking and Internet Architecture, International Journal of Computer Science and Issues, Republic of Mauritius, Jan. 2013.

[31] S. Parasakthi and P. Mohan Kumar, “EART: Enhancing an Energy Aware Routing Protocol in Cluster based Wireless Sensor Networks,” American Scientific Publishers, California, USA, vol. 13, no. 7, pp. 611-617, Jul. 2015.

[32] A. Kumar and A. Nayyar, “Energy Efficient Routing Protocols for Wireless Sensor Networks (WSNs) based on Clustering,” International Journal of Scientific & Engineering Research (IJSER), vol. 5, no. 6, pp 440-448, Jun. 2014.

[33] A. Cerpa and D. Estrin, “ASCENT: Adaptive Self-Configuring sEnsor Networks Topologies,” Technical Report UCLA/CSD-TR 01-0009, UCLA Computer Science Department, Los Angeles, Calif., May. 2001.

[34] F. Xiangning and S. Yulin, “Improvement on LEACH Protocol of Wireless Sensor Network,” *Proc. International Conference on Sensor Technologies and Applications*, pp. 260 - 264, Oct. 2007, doi:10.1109/SENSORCOMM.2007.4394931.

[35] F. Xiangning and S. Yulin, “LEACH inspired hierarchical routing protocols for wireless sensor networks,” International Journal of Information Technology, Communications and Convergence, vol. 3, no. 2, Dec. 2015.

[36] Md. Alam Hossain, Md. Kamrul Islam, Subrata Kumar Das and Md. Asif Nashiry, “Cryptanalyzing of message digest algorithms MD4 and MD5,” International Journal on Cryptography and Information Security, vol. 2, no. 1, Mar. 2012.

[37] A.C. Orgerie, M. D. Assuncao and L. Lefevre, “A survey on techniques for improving the energy efficiency of large-scale distributed systems,” International Journal on ACM Computing Surveys (CSUR), vol. 46, no. 4, Apr. 2014.

[38] J. C. Cano and P. Manzoni, “Evaluating the energy-consumption reduction in a MANET by dynamically switching-off network interfaces,” *Sixth IEEE Symposium on Computers and Communications*, pp. 186 - 191, Jul. 2001, doi:10.1109/ISCC.2001.935373.