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Fault Aware Energy Efficient Mechanisms in Cloud: A Comprehensive Survey

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Abstract- The energy consumption within cloud increases as fault or failure encountered within cloud computing. This paper presents the analysis of mechanisms used to decrease the energy consumption and enhances fault tolerance degree. The mechanisms which are discussed include both proactive and reactive fault tolerance. This study presents the comparatives analysis of techniques used to ensure fault tolerance and parameters which are enhanced through the application of the techniques. The modification to the existing techniques is required which is concluded through this proposed survey. VM Migration strategies are followed in order to migrate the load on the fittest virtual machine. This happens only if fault appears within the virtual machine. To preserve the VMs against the faults parametric comparison of existing techniques is required. Parametric enhancement is critical in future work.

Keywords- Cloud computing, VM migration, virtual machine, data centre

I. INTRODUCTION

Cloud computing is mending up the importance bit by bit. The large number of vendors and users are choosing cloud computing directives. The servers have been consumed through out the world to fulfil the needs of user for benefits which are provided by the big corporation just as (Amazon, IBM, Google).the persistent dependable organization remodelling the internal collapse and data safety are the essential issues to be move forward while giving organization to spread worldwide .Cloud computing also called as 'pay as you use' service model is affordable. It winds up striking important for the professional co-operations to assure stack adjust and solid computing order to its buyers round the regular global and having benefits implies an opportunity to utilize talents.

In this paper **Section1** represents the introduction of cloud computing and theirs basic concepts .**Section 2** define the energy efficiency of a cloud computing. **Section 3** define their challenges that are related to our work .**Section 4** define the analysis of various techniques used for energy efficiency .**Section 5** represents the conclusion and future scope.

Cloud computing and its definition

It is a model for empowering wall to wall, appropriate, on-demand network to share the resources that can be fastly provided and turn out with minimum effort.

a) Essential Characteristics

- On Demand Self-service: A user can allot counting capacity just as waiting time and network repository as desired unwillingly in the absence of user cooperation.
- Broad Network Access: Bandwidth of the network appears within this segment. Bandwidth ensures better transmission and receiving rate.
- Buffering Resources with Pool: the producers computing resources are shared to assist large number of users using multi cluster environment where resources can be allocated by checking the requirement of the users.
- Scalability: The potential can be elasticity provided and free from in some cases naturally to scale rapidly out coming and incoming comparable with demand
- Service determination: Cloud services are determined on the basis of found resources. Services are bound by service level agreement.

b) Cloud Computing Service Model

Infrastructure as a Service (Iaas): It provides the stage for holding a computing demands, computing resources and infrastructural services just as (servers, storage and networking) to configure the needed locations for organized applications example (Microsoft Azure, Amazon's Ec2). Platform as a Service (paas): The program stack takes by the user to assemble their own applications example Google apps. Software as a Service (Saas): Provides the platform for necessity and implementation for the user to use serving as Social media outlets example as Twitter, Facebook and Emails access

c) Cloud Storage: Cloud processing has engaged with great observation from different part of society. Cloud computing has gently fully grown through so many users effort[2].then there are some cloud based

practical applications deriving from cloud computing. Cloud storage is a main part of them.

The bulk users data is arise analytically [3].user's demand cannot be meeting by the ability of local machine .Therefore, peoples finding out the new ways for storing their user's data. Move behind as the advanced increased the number of users attract towards the cloud so that their data storage capacity increased.

User trying to upload the data in cloud afterwards, the cloud attender (CSP) will arise to manage their data with respect to user .In result the physical storage cannot controlled by the user which result in separation of control and running of data [6].Mean time the raider also attack the cloud service provider attendant to obtain the user's data (the data loss so that there is decrease in energy regulation) in respect of users point of view and there is reliability problem occurs.

II. CLOUD SERVICE INTERRUPTIONS

Due to increase of resources demand in cloud, flexibility Availability and reliability issue occurred in cloud so achieving the reliability and availability in cloud service is to use a Fault Tolerance Module.
The fault tolerance is the ability to continue computing processing despite the presence of a hardware failure.
The failures that occur in cloud computing can be classified into two classes

a) **Data failures:** when we send the data from one server to another, there is a data loss on a network and the failure occur due to
   - Corruption of data
   - Source data misplaced

b) Hardware failures: Hardware failure causes due to problem or malfunction of hardware. Hardware failure can result from individual component or entire system as a whole.[2] In case disk touches the storage media can also causes hardware failure. Processor failure could also causes deviation from actual output. The hardware failure occur because of

- Defective virtual machine
- Moderate virtual machine
- Storage access exception

c) Software Failure: [3]Software failure generally caused due to problem with the logic specified within the program. Exception handling also known as external abnormal condition is primary cause of it. Wrong inputs could lead to the software failure also. All such problems are transient in nature and can be rectified.

d) Transition or state related failure: [4]State shifting can lead to a problem in which system may fall within uncertain state known as race problem. This is caused due to node failure or link failure.

e) Delay distortion: [5]This failure is caused in case, system cannot produce the output in time. This type of failure can be caused by any component at any interval of time hence known as random failures.

Why it is occur?

Because of the unstable increment of energy consumption, it is basic for administrative and modern foundations to address this issue. The progression of energy-proficient cloud computing depends on advancement of a few key innovations. At the stage level, we expect some more energy-proficient mediums can be utilized as a part of cloud computing. At the hypervisor level, we expect energy-effective planning calculations, memory frameworks, storage frameworks, assets administration strategies, and so on. At the virtual machine level, we expect energy-proficient planning, correspondences, and applications.

Consequences of Failures

Failure	Consequence
Hardware Failure	All the data and resources rendered unusable
Software Failure	The virtualization will suffer greatly and virtual machine may not be used according to their capabilities
Transition Failure	This failure does not allow the conversion from input to output thus it falls under the category of processing failure
Delay Distortion	The output produced will consume huge amount of time hence waiting time is increased.

Figure1.1: Consequences of Failures

There are mainly two standard fault tolerant polices available for real time applications hosted in cloud

III. PROACTIVE FAULT TOLERANCE

a) **Passive fault tolerance:** Passive fault tolerance mechanisms tackle the faults when they appear within the system. This means these techniques allow the faults to occur within the system and then rectification mechanism are implemented to ensure fault free system. The downtime prevails for a certain time interval due to the occurrence of failure in passive approaches. It requires continuous monitoring during which huge amount of energy is consumed.The strategies under passive approach are checkpoint, replay and retry etc. Passive fault tolerant techniques decrease the effect of failures on application execution when the fault effectively happens.

b) Hyper-active Approach: Hyper-active approach allows faults to be corrected before the occurrence of it within the system. This approach is suitable in an environment having technological advancement as measures are taken to avoid faults by predicting the behavior of system at regular time intervals and decisions are made on the basis of predictions .Hyper-active approach ensures continuous and reliable service availability as zero downtime exists since decision is taken before failure. Along with fault prediction energy consumption can also be used as a key parameter for decision making in order to reduce energy consumption.Hyper-active approach has following techniques associated with it.

c) Load Balancing: [12], [13]Load balancing is the mechanism used widely in virtualization. Server load is the parameter considered in this situation. As the load on server increases, reliability is at stake. Healthy machine is such situation is selected using parameters like [14]energy conservation, [15]temperature etc. The selected machine is selected for undertaking load of deteriorating machine.

d) Primitive Migration: [16]Primitive migration is used in order to enhance the performance of the system. In this approach functions and instructions are moved to lower level of software or firmware hierarchy. The structural aspect is considered in order to perform selection of primitives for migration

e) Software Rejuvenation: [17]Software Rejuvenation is the problem arises due to aging of the software. Set of preventive techniques are utilized to prevent this situation. Initially it is necessary to classify the faults occurring within the software system. Analytical approach is applied in order to determine the optimal number of times rejuvenation is required. The accuracy of modelling is determined using metrics such as root means square error, and absolute error.

IV. REACTIVE FAULT TOLERANCE:

In Reactive Fault tolerance policy it deals with measures which are applied to reduce the effect of the faults already occurred in cloud .There are various techniques which are based on reactive fault tolerance policy like.

a) Check pointing/Restart: The state of a system that is running an application is recorded in global checkpoint and allowed to continue from that point rather restarting the application from the beginning.

b) Replication: is a process of maintaining different copies of a data item or object on different resources. Replication adds redundancy in the system.

c) Task Resubmission: In case task fails, the task is required to be resubmitted. The resubmission can be either to the same cluster or to the different cluster of virtual machine.

Live virtual machine Migration

In a physical environment if one physical host gets overloaded then there may be requirement of transfer of certain amount of data another machine with less interruption to the users. This process of data movement in virtual machine is known as data migration. In earlier times data movement requires restart before migrating the data or allocate new resources to new machine but now days by using live VM migration without downtime we can migrate the jobs. Live VM migration requires transformation states like memory, states of devices and virtual CPU etc. Furthermore, memory transfer is time consuming and requires two parameters i.e. downtime and migration time.

a) Down Time- It is the time during which services of VMs are not available.

b) Migration Time- It is the total amount of time requires transferring a virtual machine from source to destination.

Live VM migration migrate the entire OS as well as relevant applications from one physical machine to another. It provides benefits like conservation of physical server energy, load balancing and failure tolerance. Some of live VM migration techniques are given below:

a) Load Balancing Migration Techniques- In cloud environment the migration of load balancing distributes the load across the physical servers. It minimizes the resource consumption, implementation of fail over, avoiding bottlenecks, enhances scalability and over provisioning of resources etc.

b) Energy Efficient Migration Techniques- The consumption of power depends upon the utilization of servers and cooling systems. Servers mostly require 70% of power consumption even they utilize it little bit. So a migration technique is requiring conserving the energy to achieve optimum results.

c) Fault Tolerant Migration Technique- Fault tolerance is the ability of machine that works even if any part of the system get corrupted. It requires migration of one virtual physical machine to another physical machine.

Live VM migration is a two step process.

- Control is switched to the destination.
- Data transferring to the destination.

Pre-Copy- In this, first Memory is exchanged and after this execution is exchanged. The pre-copy strategy is utilized to exchange the memory to the goal node over various cycles.

Post-copy- In this, First execution is exchanged and after this, memory is exchanged. Dissimilar to pre-copy, in post duplicate the Virtual CPU and gadgets on the goal node is move in the initial step and begins the execution in second

step. Following measurements are utilized to quantify the execution of live migration.

a) Preparation-In this, assets are held on the destination which performed different tasks.

b) Downtime-Time in which the VM on the source have is suspended.

c) Resume-It does the instantiation of VM on the goal yet with an indistinguishable state from suspended source.

d) Total time-The aggregate time taken in finishing of every one of these stages is called Total Migration time.

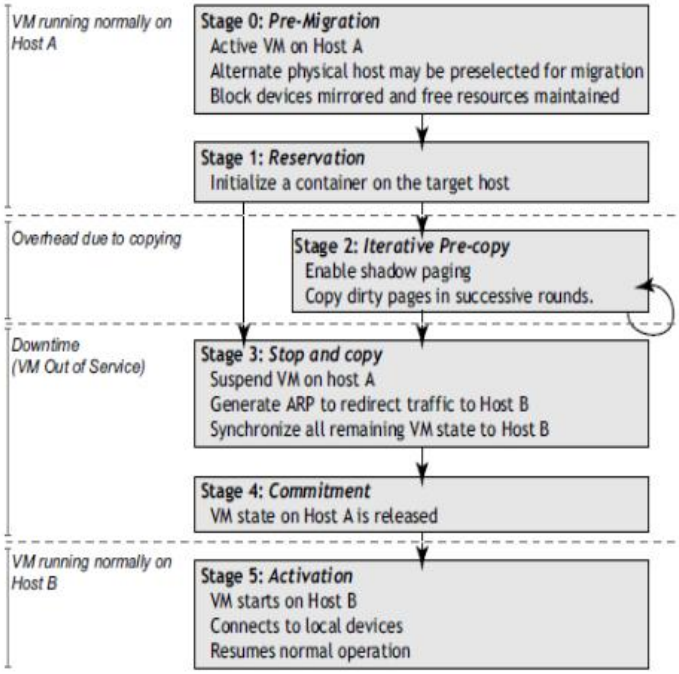

Figure1.2: Live virtual migration

V. CLOUD COMPUTING HURDLES

a) QOS CONCERNS: Quality of service takes the role of performing in resource provisioning systems under hardware and software based. It typically involves in optimization control. It can be giveback limitations so as to make slow span it for faced by the customer to which a results in obtained by quantify the span time. Qos is primarily planned to conclude facts and figures in a way that take place from top to bottom delay for each and everyone in user section is collocate rather than provisioning .Qos is used as a restraint in cost derogation based principle aside from conditions. It is allowed to count on in accumulation of cost based functions. Qos observance contained as to minimize the cost.

b) Energy Efficiency in Cloud Computing: To decrease control utilization of Data focuses is an imperative issue on account of extensive measure of power utilization. Mekinsey and Organization a counselling firm examined and expressed that on a normal just 6 to 8 level of aggregate data centre power control is utilized by their servers to perform calculations. Accordingly; it is attractive to limit energy utilization in server farms to diminish generally speaking cost.[8] Virtualization innovation merges various VMs to lesser number of hosts and enhances usage of assets to lessen energy utilization. VM consolidation can give critical advantages to cloud computing by encouraging better utilize of the accessible server farm assets. Server consolidation utilizing virtualization innovation has turned into a vital innovation for enhancing the energy proficiency of server farms.[9] The essential thought behind the server union innovation is to perform migration of Virtual Machines (VMs) to as few energy effective physical machines (PMs) as could be expected under the circumstances, and after that turn off the various PMs.[10] The basic computational issue of the server combination is fundamentally a VM choice and arrangement issue, which has been expounded in past examination. In the previous couple of years, many ways to deal with the VM consolidation issue have been proposed. In any case, existing VM union methodologies don't consider the energy overhead amid VM migration from one host to other [11] .

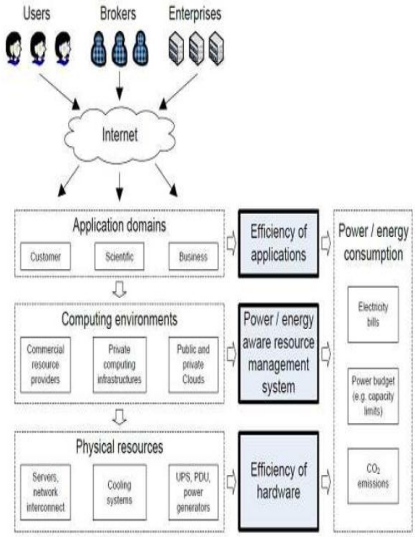

Figure 1.3: Energy consumption by various resources in Cloud data centre

As high performance frameworks develop in size and complexity, an arrangement of new challenges rise to keep an indistinguishable level of profitability from the past age

of machines. With development of systems, flexibility and energy utilization are two of the significant issues that must be tended to. Strength will turn into a fundamental concern because of substantial number of parts that will frame a machine. Such a supercomputer will have a great many processors alongside memory modules, switches and circles. With these numerous pieces, a machine is relied upon to encounter a failure at regular intervals. Power consumption management will be the driver in the outline of structures, frameworks and applications for datacenter. In a power-restricted condition, it will be vital to compel every one of the layers of the framework to meet the power spending plan.

In cloud computing major issues with datacenter are as given below:

- As cloud computing received by industry and number of client likewise quickly developing with number of datacenter with expanding power utilization.
- Load dispersed among data processing center without having data of energy consumed by them contrast with for the most part expended power in under loaded data processing center.
- Current load adjusting techniques concentrate on load balance when request load increases but not as consumed power increases.
- High loaded data service center consume more energy to process tasks and might be because of high load data service centers back off which isn't useful for client also cloud supplier.
- Some processing centers having less load contrast with overloaded datacentre's and they are under most extreme load however high loaded processing centers computing them with high energy utilization.
- Some request are need to be computed within it's time line yet because of high load they may miss their due date which isn't suitable to client and will be a basic issue. Requests having less finishing time can be register on slightest or power consuming computation centers.
- According to late investigation, use of data gathering centers has real issue because 60% datacentres are idle and the greater part of 20% data gathering centers are completely use and wastes of energy individually. This show poor usage of assets also controls yet this shows significance of new approach that has adequate procedure to limit waste of energy as much as.
- Request compose have enormous effect of administrations, if demands are private at that point specialist co-op needs to take it as high need and low need to open.

Energy Consumption in Cloud Computing

The energy preservation in cloud computing notably in estate is a crucial interest for the analysis. Their techniques for conservation in cloud computing can be sectioned as

a) Energy efficient hardware: The Speed Step automation offer by Intel empower the structure alter voltage and primary something occur at a particular amount of time positively in a manner of load which in cause to reduce the power and heat group. Power Now is a technique offer via AMD which minimize power used in processors through reducing CPU clock rate including basic voltage is diminish, at time when processor is inactive so as to decrease final power utilization and lower heat production, permit for moderate cooling action. Rise in hardware automations have lower energy dissipation to a definite level but it will persist a prime cover as a energy utilized by hardware resources is overblown by their consumption, point at originate required for utilized the blooming based on software energy reducing strategy.

b) Energy aware scheduling: Energy well informed to a system known as Dynamic voltage Scaling programme collective many problem solving task in multiple systems for effectively decreases processors strength a period of time insure proper working in the middle of, DVS review handling the job fulfilment phase in order to split up the call of duties .The schedule does not attain energy turnout markedly driven to cpu lead down the voltage decidedly less productive when analogize the turnout system idle orderly split up their steading state make their alike power

c) Consolidation

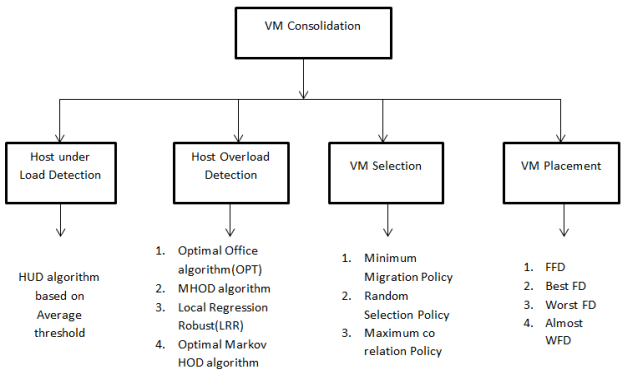

Figure 1.4: Subdivision of VM consolidation problem

Energy productive use of server farm assets can be done in two stages. The initial step is proficient position of VMs and second is the improvement of the assets allotted in initial step utilizing live migration as the asset request changes.

d) Virtual machine placement: Position objective can augment the utilization of accessible assets or it can spare of energy. In view of situation objective,[14] in our exploration extensively arranged VM Placement calculations as takes after:

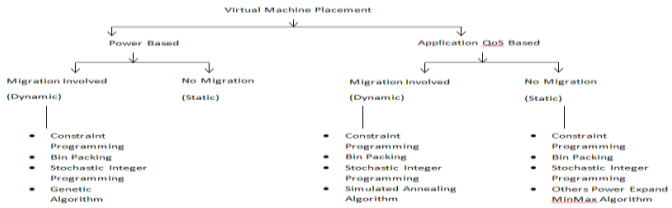

Figure1.5: Classification of VM Placement Algorithms

Constraint Programming: It is a sort of logic programming, as a difference to scientific methodologies, to take care of complex combinatorial issue of ideal VM situation. It utilizes an arrangement of requirements which can without much of a stretched out further to include more perspectives [15]

- Each virtual machine can be hosted on only one physical machine;
- For each type of resource, the amounts of resource requests of virtual machines sharing the same physical machine are smaller or equal to capacity of physical machine hosting them;
- The number of physical machines that host virtual machines are not more than m=,∑mj=iyi≤m

Bin Packing: Bin packing is the mechanism of executing cloudlets by using fitting approach. This fitting approach is on the basis of selection of virtual machines with resources. The resources are collected within the pool. This pool is known as bin. The cloudlets have to be packed into the resource pool or bins. The mechanism followed in order to do so is known as bin packing. The bin packing mechanism is efficient strategy to determine overloaded VM and to decrease the load of the virtual machine. Requirement corresponding to the load is determined from individual VM and it lets the performance to enhance by shifting the overloaded VM to distinct VMs using the bin packing approach [16]

Bin packing representation scheme: There are three representations for resolving bin packing

a) Bin based representation: in bin packing approach iterative approach for load balancing is used. The chromosomes corresponding to number of objects are declared. As the chromosomes are selected there fitness is evaluated. As the fittest chromosomes are selected, they are chosen for load allocation. The load allocation strategy or process is repeated until the profit is maximised or cost is reduced significantly. The problem with this approach is slow convergence rate.

b) Object based representation: In the object-based representation, a chromosome represents a permutation of objects. Then the chromosome is partitioned based on number of objects placed in bins.

c) Group based representation: This representation is in fact group oriented, and represents the most adequate and best suited to the representation of the problem. It is more important to know how the objects are grouped together as to how they are placed. This method involves two phases, the first looks like the bin-based representation. The second phase represents an encoding of the bins used in a one-to-one correspondence to genes.

Stochastic Integer Programming: Stochastic integer programming problems combine the difficulty of stochastic programming with integer programming. It is a multi-objective optimization model to handle SLA-aware service composition problem. It provides a set of solutions that are multiple based on multiple SLAs [17]

- A dynamic server migration
- An optimized server consolidation
- Dynamic server migration:

It reduces SLA violation by reducing the amount of physical capacity required. The management algorithm (MFR) dynamically remaps VMs to PMs required, so as to reduce the SLA violation .The combination of Bin packing heuristics and Time series forecasting techniques are used to reduce the number of physical machines used.

Server Consolidation: An Optimized Server Consolidation: It introduced a capacity planning approach to minimize the number of server used and their operational cost .This approach combines data preprocessing approach and an optimization model.

Genetic Algorithm: It is a way through which we can generate population by using biological concept. GA is viewed as a quickly developing area of Artificial intelligence. By Darwin's hypothesis of development was used the Genetic Algorithms (GAs). As indicated by Darwin's hypothesis, term "Survival of the fittest" is utilized as the strategy for planning in which the tasks are appointed to assets as per the estimation of fitness function for every parameter of the assignment scheduling process [18] .

- **Selection** which equates to survival of the fittest.
- **Crossover** which represents mating between individuals.

- **Mutation** which introduces random modifications.

VI. LIVE VIRTUAL MACHINE MIGRATION FOR VM PLACEMENT OPTIMIZATION

[19]Live VM migration exchanges the memory condition of a VM from one PM to other encouraging continuous administrations to the running applications. Any live VM migration brings about migration downtime amid which the administrations running on that VM gets influenced, henceforth the lower the better.[20] In our examination depicts that every one of the calculations which endeavour to allocate the resource to the virtual machines using the four pre-requisites - (1)Determining when the server corresponding to the host is loaded with extra tasks; (2) deciding when a host is considered as under-stacked; determination of VMs that ought to be relocated from an over-burden have; finishing another position and result is produced at different virtual machine due to overloading[21] Following table portrays them concisely and abridges the abnormal state objectives while noting these inquiries for each of the coveted objectives:

Goals	Server Consolidation	Load balancing	Hotspot Migration
Migration starting process	Identifying least load VM	Increased load on physical machine	Checking for hotspot to determine optimal VM of migration
Optimal VM identification for load allocation	Lightly loaded VM selection	VMs selection from over burdened machines	Selecting cluster of VMs for migration in case of heavy load
Checking datacenter for location identification for migration	Determine load of physical machine	Determining machine having loaded VM	Physical machines using lightly low load checking

Figure1.6: Live Virtual Machine Migration

CLOUD COMPUTING PROVOCATION

In order to help end-client applications and to offer services to the clients, specialist organizations like Amazon [24], HP [25], and IBM [26] have opened their cloud information centre all through the world. Cloud has applications in relatively every field from medicinal services to generic content handling programming. After applications get facilitated on cloud platform, anybody can approach these services at anywhere, with any gadget having Internet. On backend, virtualized PCs are utilized for their processing power; in this manner speed of the application is expanded for the clients that compensation for the services really utilized. There are numerous challenges additionally in the utilization of these cloud services which must be taken care of viably keeping in mind the end goal to make cloud benefits more dependable, secure, and cost-effective. Some of the open challenges are-

a) **Cloud Storage:** Cloud storage theoretically is infinite however with the increasing demands of the users; this storage capacity is under stakes. In order to tackle the issue, cloud storage is required to be optimized. This can be accomplished by identification of critical information that must be transmitted at first place into the memory and rest if given least priority.

b) **Quality of service**: Cloud service provider over the network is many and every cloud service provider requires mass users. To accomplish this, Quality of Service becomes key parameter. Quality of service is ensured in case services provided by CSP are up to the mark. Quality of service is ensured through the services provided by the CSP. Services provided by CSP are bound by SLA. SLA violation and its rectification by continuously monitoring SLA in proposed work. It is vital for the Cloud service providers (CSPs) to guarantee that attractive measure of cloud assets are constantly provisioned keeping in mind the end goal to satisfy Quality of service prerequisites of Cloud service consumers (CSCs) like due date, reaction time, and spending requirement. Reason for SLAs (Service Level Agreements) is shaped by this Quality of service prerequisites and infringement in any frame will prompt penalty. Along these lines dynamic provisioning of right number of assets in a convenient and correct way is done to maintain a strategic distance from or limit the violations.

c) **Dynamic Resource management:** Every datacenter within cloud has limited resources associated with it. In case requirement is not fulfilled by the datacenter then job must be allotted to some other datacenter. There must be a provision to add new resources as and when required depending upon the needs of the user. This is known as dynamic resource management.

d) **Fault Tolerance:** Faults cause deviation from actual result. To tackle the situation fault tolerance strategies comes into existence. Fault tolerance however ensure delay in failure but parameters like energy consumption, load balancing, delays etc can be degraded. To tackle the issue power aware strategy for tackling faults can be proposed. A system must tolerate the software or hardware faults and work properly without any failure. The main advantages of having fault tolerant systems are recovery from the failure, cost is lowered, performance metrics are improved etc.

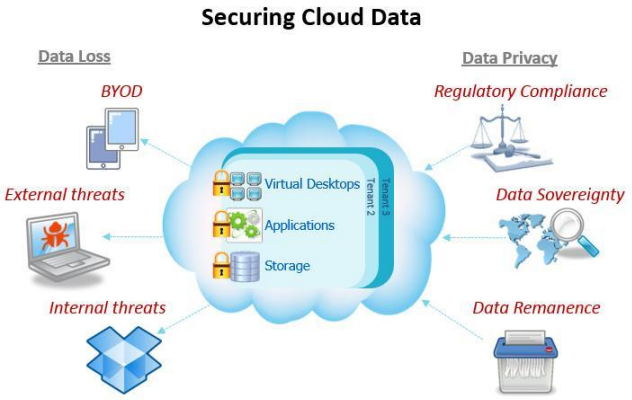

Figure1.7: Securing cloud data

1. Pricing in Cloud Computing: Cloud computing provides on demand service so the users must get all the services uninterrupted for which they are paying also. Services are provided through SLA's (Service Level Agreements) which take place between customers and providers. There is a need to make cloud computing environment in which SLA violations are minimized.

e) Load Balancing: It means load should be balanced among the cloud components. Load must be distributed evenly and uniformly among all the nodes. Load can be related to memory, network, and storage or processing power. Centralised approach is not that efficient in the handling of load balancing of resources among the nodes. Therefore more decentralized approach is needed.

f) Energy Efficiency: Energy efficiency is prime concern while allotting resources to the jobs known as cloudlets. As cloudlets are allotted resources energy is consumed. In case size of the cloudlet is high then excessive energy is consumed. This energy consumption can be due to hardware or software. This could be due to load balancing problems also. in order to tackle the issue, fittest VM must be selected for allocation of resources at first place.

1. **Energy Efficient Hardware:** Before allocation of resource, uptime of hardware from where VM is derived is required to be checked. Higher the value of Uptime less fault tolerant system will be. Hence more energy will be consumed. Low uptime datacenter thus must be selected for operation.
2. **Energy aware scheduling**: Scheduling is the mechanism of achieving least waiting time. Least amount of stress is paid towards energy consumption. In case, energy consumption is focused upon then Makespan and Flowtime associated with the job can be further minimized.
3. **Consolidation:** Once the VM is faulted, it cannot execute the task further. The task is again required to be executed again from the beginning. This will consume more energy than normal. To tackle the issue, shadows of the VMs can be maintained, so that in case of failure of current core within VM, task can be executed on another core within same VM. Process can lead to decrease in energy consumption.
4. **Virtual machine migration:** In case of failure, entire work done by the current VM is lost. The failure initiates migration. Live VM migration can be preferred rather than offline migration due to increase in time consumption and hence energy. Live VM migration can decrease energy consumption in terms of downtime and migration time.

VI. ANALYSIS OF VARIOUS TECHNIQUES USED FOR ENERGY EFFICIENCY

[22] It describes a technique that is used for energy efficiency in virtual integration without sacrificing the Qos. The algorithm that was proposed is dynamic and utilizes the local search for determining the number of virtual machines over a cloud and total energy cost in the system. The proposed algorithm provides an adaptable strategy to build the energy efficiency of the distributed computing framework or even increment the asset accessibility in the datacenter. Cloud supplier can choose how to benefit VMs with huge handling asset necessities and how to disseminate their solicitations among the servers to amplify the energy efficiency. But it does not consider the copied VM over the cloud and also the processing requirement by factor can also be increased.

[23] Proposes an algorithm based on genetic algorithm that considers the demands of machines made previously and also the present demands. The utilization of power can be minimized by using the physical machine and keeping all other machine in power saving mode. This algorithm balances load along with minimizing power consumption over the cloud. Moreover it does not consider constraints over the virtual machines that are dependent over a single physical machine.

[23] The algorithm main aim is to completely use a host by utilizing virtual machines. The two principle undertakings in cloud computing are VM distribution and assignment

planning. The point is to utilize insignificant number of hosts, productive load adjusting (dynamic), low reaction/turnaround time, and low power utilization. In this paper, all VMs are available in a single server canter. Subsequently it does not considering the components like system/web transmission capacity while ascertaining delays accordingly time (as per separate b/w client and the server farm).

[24] This paper is used to serve more demands at a specific time allotment, the physical machines ought to be utilized viably i.e., the VM placement strategy should be such that load on individual physical machine decreases considerably. In order to do so, virtual machines must be sorted in order to reduce the utilization of PM. In this the depiction of proposed strategy named VM Scheduler for virtual machine arrangement has been done. From the outcomes got obviously the proposed VM Scheduler is performing much superior to anything other examined position arrangements as far as limiting cost, limiting designation time and limiting SLA infringement. VM relocation is the process of placing the VMs in ascending order of load allocation. The more loaded VMs can be placed lower down within the virtual machine list. This sequence decreases the cost associated with the overall approach. This approach is missing in considered literature.

[25] This work introduces a broad progressive survey of the most important VMP writing with a specific end goal to distinguish look into circumstances. Cloud Computing Datacenters have a great many virtual machines (VMs) on genuine situations. In this specific circumstance, Virtual Machine Placement (VMP) is a standout amongst the most difficult issues in cloud foundation administration, considering likewise the extensive number of conceivable streamlining criteria and diverse details that could be contemplated. VMP writing incorporate important subjects, for example, energy-efficiency, Service Level Agreements (SLA), cloud benefit markets, Quality of Service (QoS) and carbon dioxide outflows, every one of them with high practical and environmental effect.

[26] Depicts a target strategy that can be utilized to look at VM-situation calculations in substantial clouds, covering a huge number of PMs and a huge number of VMs. It also exhibits a strategy by looking at 18 calculations for starting VM position in on-request foundation clouds. It looks at calculations enlivened by open-source code for framework clouds, and by the online canister pressing writing. Much late research has been committed to exploring calculations for dispensing virtual machines (VMs) to physical machines (PMs) in foundation clouds. Numerous such calculations address unmistakable issues, for example, starting arrangement, solidification, or tradeoffs between respecting administration level understandings and compelling supplier working expenses. Indeed, even where comparable issues are tended to, every individual research group assesses proposed calculations under particular conditions, utilizing different procedures, frequently focused to a little gathering of VMs and PMs. [27]

[28] It proposed a GGA algorithm. GGA works well in most of the cases, irrespective of the number of constraints being high or low. It is important to choose a feasible initial solution, because the genetic operators are applied to this solution. In order to get a solution in fixed time, this can put a restriction on the number of generations. Thus, it may end up not getting the optimal solution, but the solution will be better than the one it had begun with.

[8]proposed a multi heuristic approach to deal with load balancing. Load balancing uses the mechanism to reduce the load on individual machine. The machine with overloaded cloudlets is discarded and machines with light load are used for operation. The operation gives the better result in terms load balancing degree.

[81] This paper does not consider the system reliability for energy efficiency in virtual resources. It also does not consider parameters like communication overhead, the voltage switching overhead. In our proposed paper we consider all these parameters and also along with these network resources have been consider.

[82] This paper does not consider the performance in SLATAH metric. The use of software packages for real world performance evaluation is not considered in the algorithm given. In our proposed paper we evaluate real world performance for efficient use of resources and also performance level can be enhanced.

[83] It describes a method named MDEP (Minimal Data Accessing Energy Path) for energy consumption and VM deployment. This paper does not consider adaptive methods like workload aware and load balance. In proposed paper VM scheduler with Load balance has been consider and energy aware VM migration also designed.

[84] In this algorithm a precise workload prediction algorithm has been given but it does not consider resource utilized rate. In our proposed paper we will consider resource utilized rate and also some model to clearly predict workload.

Table.1

Reference	Down Time	Migration Time	Energy Consumption	Reliability	Load Balancing
(Singh & Moser 2005)	Down time is accomplished by using pre filter copy algorithm	To migrate the load between virtual machines migration time is	-------S----------	resource management and task assignment in cloud	load balancing degree is managed by migrating the jobs from one VM

		used to accomplish this task pre filter copy algorithm is used		environment for reliability enhancement	to another
(Diouri et al. 2013)	----------	----------	Energy consumption is achieved by using VM scheduler	Utility-Based Job Scheduling Algorithm are used for Cloud Computing Considering Reliability Factor	Opportunistic Load Balancing:
(Egwutuoha et al. 2013)	Characteristic Based Compression (CBC) algorithm is used to achieve down time	Characteristic Based Compression (CBC) algorithm is used to achieve migration time	task scheduling using Clonal Selection Algorithm (TSCSA) to optimize energy consumption	----------	Load balancing is achieved using dynamic load balancing techniques
(Computing et al. 2015)	GA is used to reduce down time	Migration time is reduced using genetic algorithm	----------	Resource management is performed to achieve reliability	----------
(Bala & Chana 2015)	Slow scheduling algorithm is used to reduce down time	Slow scheduling algorithm is used to reduce migration time	----------	Task scheduling using CSA is used to achieve energy efficiency	----------
(Zhang et al. 2010)	----------	----------	Task scheduling using CSA is used to achieve energy efficiency	resource management and task assignment in cloud environment for reliability enhancement	----------
(Jhawar et al. 2012)	Memory compression based VM migration approach is used to reduce down time	Memory compression based VM migration approach is used to reduce migration time	----------	Utility-Based Job Scheduling Algorithm are used for Cloud Computing Considering Reliability Factor	----------

VII. CONCLUSION

Massive population becomes client of the cloud due to high availability of resources at very affordable price. As more and more users interact and use cloud, resource availability becomes vulnerable. Energy consumption associated with datacenters within the cloud becomes a great problem. Research has been done towards saving energy consumption but yet there is room for improvement corresponding to energy efficiency. This paper provides a comprehensive survey of techniques which are used to detect the abnormal situations causing high energy consumption. Comparative table suggests in most of the existing system work has been done towards migration time and downtime but VM splitting is missing.

In future VM splitting approach can be merged along with energy efficient mechanisms for parametric enhancement.

REFERENCES

[1] Mills, T. Znati, R. Melhem, K. B. Ferreira, R.E.G., 2011. Energy Consumption of Resilience Mechanisms in Large Scale Systems. *Proc. of IEEE Int'l Conf. Comput. Design (ICCD '11*.

[2] A. Beloglazov, R.B., 2010. Energy Efficient Allocation of Virtual Machines in Cloud Data Centers. *10th IEEE/ACM International Conference on Cluster, Cloud and Grid Computing*.

[3] A. Beloglazov, J. Abawajy, R.B., 2012. Energy-aware resource

allocation heuristics for efficient management of data centers for Cloud Computing. *Future generation Computer System*, pp.755–768.

[4] A. Zhou, S. Wang, Z. Zheng, C. Hsu, M. Lyu, and F.Y., 2014. On cloud service reliability enhancement with optimal resource usage. *IEEE Transactions on Cloud Computing,*, 1(1), pp.1–1.

[5] A.Avinzienis, J.CLapne, B.randell, C. landweh., 2004. Basic Concepts and Taxonomy of dependable and secure computing. *IEEE Transaction*, 1, pp.11–33.

[6] Anon, INDIA'S ENERGY SCENARIO 2020,2014,IEEE.

[7] Anton Beloglazov, R.B., 2012. Optimal Online Deterministic Algorithms and Adaptive Heuristics for Energy and Performance Efficient Dynamic Consolidation of Virtual Machines in Cloud Data Centers. *Concurrency and Computation: Practice and Experience (CCPE), Wiley Press*, pp.755–768.

[8] Arvind Kumar, A.B., 2015. "Improved EDF Algorithm for Fault Tolerance with Energy Minimization." *In Computational Intelligence & Communication Technology (CICT), 2015 IEEE International Conference*, pp.370–374.

[9] Asai, H., 2013. P2V Migration with Post-copy Hot Cloning for Service Downtime Reduction. *IEEE Third International Conference on Cloud and Green Computing*, pp.1-8.

[10] B.P. Rimal, E.C., 2009. A taxonomy and survey of Cloud Computing Systems. *IEEE Fifth International Joint Conference on INC, IMS and IDC*, pp.44–51.

[11] Bakhta Meroufeland, G.B., 2014. Adaptive time-based coordinated checkpointing for cloud computing workflows. IEEE *Scalable Computing: Practice and Experience*, pp.153–168.

[12] C. Engelmann, G. R. Vallee, T. Naughton, and S.L.S., 2009. Proactive Fault Tolerance Using Preemptive Migration.IEEE*Euromicro International Conference on Parallel, Distributed and Network-based Processing,*, pp.252–257.

[13] C. N. Höfer, G.K., 2011. Cloud computing services: taxonomy and comparison. *Journal of Internet Services and Applications, Springer*.

[14] C.C. Meixner, C.Develder, M.Tornatore, B.M., 2015. Survey on Resiliency Techniques in Cloud Computing Infrastructures and Applications. *IEEE*.

[15] Chua, A.D.G.K.C., 2015. Time-aware VMFlow Placement, Routing and Migration for Power Efficiency in Data Centers. *IEEE Transactions on Network and Service Management*,, pp.349–362.

[16] D. Boru, D. Kliazovich, F. Granelli, P. Bouvry, A.Z., 2013.IEEE, Energy-Efficient Data Replication in Cloud Computing Datacenters. *CCSNA workshop at Globecom*.

[17] D. Jung, S. Chin, K. Chung, and H.Y., 2013. VM migration for fault tolerance in spot instance based cloud computing. *in Grid and Pervasive Computing, Springer,*, pp.142–151.

[18] D. Sun, Guiran, Chang, C. Miao, X.W., 2013. Analyzing, modeling and evaluating dynamic adaptive fault tolerance strategies in cloud computing environments. *Springer Science+Business Media New York*.

[19] Daeyong Jung, SungHo Chin, KwangSik Chung, HeonChang Yu1, J.G.", 2011. An Efficient Checkpointing Scheme Using Price History of Spot Instances in Cloud Computing Environment. IEEE,*IFIP International Federation for Information Processing*, pp.185–200.

[20] Di, Y. Robert, F. Vivien, D. Kondo, C. Wang, F.C., 2013. Optimization of Cloud Task Processing with SPRINGER,Checkpoint-Restart Mechanism. *ACM*.

[21] E. Feller, L. Rilling, C. Morin, R. Lottiaux, and D.L., 2010. Snooze: A Scalable, Fault-Tolerant and Distributed Consolidation Manager for Large-Scale Clusters. *Proc. 2010 IEEE/ACM Int'l Conference on Green Computing and Communications & Int'l Conference on Cyber, Physical and Social Computing*, (125-132).

[22] El-Sayed, Nosayba, and B.S., 2014. To checkpoint or not to checkpoint: Understanding energy-performance-I/O tradeoffs in HPC checkpointing. *Understanding energy-performance-I/O tradeoffs in HPC checkpointing.", IEEE Cluster Computing (CLUSTER)*.

[23] Enida Sheme , Neki Frashëri , Simon Holmbacka, Sébastien Lafond, D.L., 2016. Datacenters powered by renewable energy: A case study for 60 degrees latitude north. IEEE, *Software, Telecommunications and Computer Networks (SoftCOM)*.

[24] Eun Kyung Lee, Hariharasudhan Viswanathan, D.P., 2015. Proactive Thermal-aware Resource Management in Virtualized HPC Cloud Datacenters. *IEEE Transactions on Cloud Computing,*, pp.1–14.

[25] F. Ma, F. Liu, and Z.L., 2010. Virtual machine migration based on improved pre-copy approach,. *In Proc. IEEE Int'l Conf. Software Engineering and Service Sciences,*, pp.88–97.

[26] Fahimeh Farahnakian, Adnan Ashraf, Tapio Pahikkala, Pasi Liljeberg, Juha Plosila, Ivan Porres, and H.T., 2015. Using Ant Colony System to Consolidate VMs for Green Cloud Computing. *IEEE Transactions on Services Computing,*, pp.184–198.

[27] Gartner, F., 1999. Fundamentals of fault-tolerant distributed computing in asynchronous environments. *ACM Computing Surveys*, 31(1),IEEE pp.1–26.

[28] Goiri, F. Julia, J. Guitart, and J.T., 2010. Checkpoint-based fault tolerant infrastructure for virtualized service providers,. *Proc. IEEE/IFIP Network Operations and Management Symposium (NOMS'10)*, pp.455–462.

[29] H. Goudarzi, M.P., 2012. Energy-Efficient Virtual Machine Replication and Placement in a Cloud Computing System. *Computing, IEEE Fifth International Conference on Cloud*, pp.750–759.

[30] H. Jin, L. Deng, S. Wu, X. Shi, and X.P., 2009. Live virtual machine migration with adaptive, memory compression. *In Cluster Computing and Workshops, 2009. CLUSTER '09. IEEE Inter-national Conference on*, pp.1–10.

[31] I. Egwutuoha, S. Chen, D. Levy, B. Selic, R.C., 2013. Energy efficient fault tolerance for high performance computing (hpc) in the cloud. *Sixth International Conference on Cloud Computing (CLOUD), IEEE, ,*, pp.762–769.

[32] Ibtesham, Dewan, David DeBonis, Dorian Arnold, and K.B.F., 2014. Coarse-Grained Energy Modeling of Rollback/Recovery Mechanisms. *InDependable Systems and Networks (DSN), 2014 44th Annual IEEE/IFIP International Conference*, pp.708–713.

[33] J. Ansel, K. Arya, and G.C., 2009. DMTCP: Transparent checkpointing for cluster computations and the desktop,. *in Proc. of the Int'l Parallel and Distributed Processing Symp. (IPDPS). Rome, Italy IEEE*, pp.1–12.

[34] J. Wei, L. Rashid, K.P. and S.G., 2011.IEEE, Comparing the effects of intermittent and transient hardware faults on program. *in Procs. DSN-W*.

[35] Jhawar, R. and Puri, V., 2012. Fault tolerance Management in IaaS clouds. *IEEE first AESS European Conference*, (ESTEL), pp.pp.1–6.

[36] Johnson, J.A., 2013. Optimization of migration downtime of virtual machine in Cloud. *IEEE*, pp.1–5.

[37] Justin Moore , Jeffrey S. Chase, P.R., 2006. "Weatherman: Automated, Online, and Predictive Thermal Mapping and Management for Data Centers. *IEEE International Conference on Autonomic Computing*, pp.155–164.

[38] K. Kourai, S.C., 2007. A Fast Rejuvenation Technique for Server Consolidation with Virtual Machines. *IEEE International Conference on Dependable Systems and Networks*.

[39] Karanbir Singh, S.K., 2016. Energy Efficient Resource Provisioning Through Power Stability Algorithm in Cloud Computing",. *Proceedings of the International Congress on Information and Communication Technology, Springer*, pp.255–263.

[40] Kim Khoa Nguyen, M.C., 2015. Environment-aware Virtual Slice Provisioning in Green Cloud Environment. *IEEE Transactions on Service Computing,*, pp.507–519.

[41] Kim, Changhyeon, C. Jeon, W. Lee, and S.Y., 2015. A Parallel Migration Scheme for Fast Virtual Machine Relocation on a Cloud Cluster. *The Journal of Supercomputing, Springer,*, pp.4623–45.

[42] L. Silva, J. Alonso, and J.T., 2009. Using Virtualization to Improve Software Rejuvenation. *IEEE Trans. Computers*, 58(11), pp.1525–1538.

[43] Lin Wang, Fa Zhang, Jordi Arjona Aroca, Athanasios V. Vasilakos, Kai Zheng, Chenying Hou, Dan Li, and Z.L., 2014. GreenDCN: A General Framework for Achieving Energy Efficiency in Data Center Networks. *IEEE Journal on Selected Areas in Communications*, pp.4–15.

[44] Liu, Jialei, S. Wang, Ao Zhou, S.A P Kumar, and R.B., 2016. Using Proactive Fault - Tolerance Approach to Enhance Cloud Service Reliability. *IEEE Transactions on Cloud Computing*, pp.1–13.

[45] M. A. Haque, H. Aydin, D.Z., 2011. Energy-Aware Standby-Sparing "Technique for Periodic Real-Time Applications. *Proc. of IEEE Int'l Conf. Comput. Design (ICCD '11*.

[46] M. Castro, B.L., 2002. Practical byzantine fault tolerance and proactive recovery. *ACM Transactions on Computer Systems (TOCS)*, 20(4), pp.398–461.

[47] M. Grottke, R. Matias, and K.T., 2008. The fundamentals of software aging. *IEEE International Conference*.

[48] M. Salehi, M. K. Tavana, S. Rehman, M. Shafique, A. Ejlali, and J.H., 2016. wo-State Checkpointing for Energy-Efficient Fault Tolerance in Hard Real-Time Systems. *IEEE TRANSACTIONS ON VERY LARGE SCALE INTEGRATION (VLSI) SYSTEMS*, pp.1–12.

[49] M. Zhao, F. DUgard, K.A. Kwait, C.A.K., 2015. "Multi-level VM replication based survivability for mission-critical cloud computing." *IEEE International Symposium on Inegrated Network Management*.

[50] M.Lackovic, D.Talia, R.T. Calasanz, J.Banares, and O.R., 2010. A taxonomy for the analysis of scientific workflow faults. *Proceedings of the 13th IEEE International Conference on Computational Scienceand Engineering.*, pp.398–403.

[51] M.R. Hines, K.G., 2009. Post-Copy Based Live Virtual Machine Migration Using Adaptive Pre-Paging and Dynamic Self-Ballooning. *Proceedings of the 2009 ACM SIGPLAN/SIGOPS international conference on Virtual execution environments,*, pp.51–60.

[52] Mahdi Ghamkhari, H.M.-R., Energy and Performance Management of Green Data Centers: A Profit Maximization Approach. *IEEE Transactions on Smart Grid*, 2014, pp.1017–1025.

[53] Mehmet Basoglu, Michael Orshansky, M.E., 2010. NBTI-Aware DVFS: A New Approach to Saving Energy and Increasing Processor Lifetime. *IEEE International Symposium on Low-Power Electronics and Design*, pp.253–258.

[54] P. Chi, Cong Xu, T. Zhang, X. Dong, Y.X., 2014. Using Multi-Level Cell STT-RAM for Fast and Energy-Efficient Local Checkpointing. *IEEE*.

[55] P. Das, P.M.K., 2013. VFT: A Virtualization and Fault Tolerance Approach for Cloud Computing. *Proceedings of 2013 IEEE Conference on Information and Communication Technologies(ICT 2013)*, pp.473–478.

[56] P.D. Kaur, K., 2015. Fault Tolerance Techniques and Architectures in Cloud Computing-A Comparative Analysis. *IEEE*.

[57] Qi Zhang, Lu Cheng, R.B., 2010. Cloud computing: state-of-the-art and research challenges. *J Internet Serv Appl (2010), springer*, pp.7–18.

[58] R. Jhawar, V.P., 2013. Fault Tolerance and Resilience in Cloud Computing Environments. *Computer and Information Security, IEEE*.

[59] R. Melhem, D. Mosse, E.E., 2004. The Interplay of Power Management and Fault Recovery in Real-Time Systems. *IEEE TRANSACTIONS ON COMPUTERS*, 53(2).

[60] R. Rajachandrasekar, A. Venkatesh, K. Hamidouche, D.K.P., 2015. Power-Check: An Energy-Efficient Checkpointing Framework for HPC Clusters. *15th IEEE/ACM International Conference on Cluster, Cloud and Grid Computing,*, pp.261–271.

[61] S. Agarwal, R. Garg, M. S. Gupta, and J.E.M., 2004. Adaptive incremental checkpointing for massively parallel systems. *In ICS '04: Proceedings of the 18th Annual International Conference on Supercomputing ACM*, pp.277–286.

[62] S. Marc, Robert W. Wisniewski, J.A. Abraham, S.V.Adve, S. Bagchi, P. Balaji, J.B. et al., 2014. Addressing failures in exascale computing. *International Journal of High Performance Computing Applications*, 28(2), pp.129–173.

[63] Salfner.F, Leck, M. and M., 2010. A survey of online failure prediction methods. *ACM Computing Surveys(CSUR)*, 42(3), p.p.10.

[64] Shangguang Wang, Ao Zhou, Ching-Hsien Hsu, Xuanyu Xiao, F.Y., 2016. Provision of Data-intensive Services through Energy- and QoS-aware Virtual Machine Placement in National Cloud Data Centers. *IEEE Transactions on Emerging Topics in Computing*, pp.290–300.

[65] Su, W. Chen, G. Li, Z.W., 2015. RPFF: A Remote Page-fault Filter for Post-copy Live Migration. *IEEE International Conference on Smart City/SocialCom/SustainCom together with DataCom*, pp.936–943.

[66] T. Mastelic , A. Oleksiak , H. Claussen , I. Brandic , J.M. Pierson, A.V.V., 2015. Cloud Computing: Survey on Energy Efficiency. *ACM Computing Surveys (CSUR)*, 47(2), pp.1–36.

[67] Vaibhav Sundriyal, M.S., 2013. Initial Investigation of a Scheme to Use Instantaneous CPU Power Consumption for Energy Savings Format. *E2SC '13 Proceedings of the 1st International Workshop on Energy Efficient Supercomputing*.

[68] Vijaykumar, F.A. and T.N., 2010. Joint optimization of idle and cooling power in data centers while maintaining response time. *ACM SIGPLAN,*, pp.48–55.

[69] W. Lang, J.M. Patel, J.F.N., 2009. On Energy Management, Load Balancing and Replication. *ACM SIGMOD Record*, pp.35–42.

[70] Wei Deng1, Fangming Liu1, Hai Jin1, Bo Li, D.L., 2014. Harnessing renewable energy in cloud datacenters: opportunities and challenges. *IEEE Network*, pp.48–55.

[71] X. Cui, T. Znati, R.M., 2016. Adaptive and Power-Aware Resilience for Extreme-Scale Computing. *Intl IEEE Conferences*, pp.1–9.

[72] X. You, L. Zhou, J. Huang, J. Zhang, C.J. and J.W., 2013. E2ARS : An Energy-Effective Adaptive Replication Strategy in Cloud Storage System,. *Applied Mathematics & Information Sciences An International Journal IEEE*, pp.2409–2419.

[73] X. Zhang, Z. Huo, Jie Ma, D.M., 2010. Exploiting Data Deduplication to Accelerate Live Virtual Machine Migration. *IEEE International Conference on Cluster Computing,*, pp.88–97.

[74] Y. Abe, R. Geambasu, K. Joshi, M.S., 2016. Urgent Virtual Machine Eviction with Enlightened Post-Copy. *12th ACM SIGPLAN/SIGOPS International Conference on Virtual Execution Environments,*, pp.51–64.

[75] Y. Lin, H.S., 2017. EAFR: An Energy-Efficient Adaptive File Replication System in Data-Intensive Clusters. *IEEE Transactions on Parallel and Distributed Systems,*, pp.1017–1030.

[76] Y. Ma, H. Wang, J. Dong, Y. Li, and S.C., 2012. ME2: efficient live migration of virtual machine with memory exploration and encoding. *IEEE International Conference on Cluster Computing*, pp.610–613.

[77] Yeo, R.B. and C.S., 2009. Cloud Computing and Emerging IT

Platforms: Vision, Hype, and Reality for Delivering Computing as the 5th Utility. *Future Generation Computer Systems*, 25(6), pp.599–616.

[78] Yi Ren, Junichi Suzuki, Chonho Lee, Athanasios V. Vasilakos, S.O., 2014. Balancing Performance, Resource Efficiency and Energy Efficiency for Virtual Machine Deployment in DVFS-enabled Clouds: An Evolutionary Game Theoretic Approach. *GECCO Comp '14: Proceedings of the Companion Publication of the 2014 Annual Conference on Genetic and Evolutionary Computation*.

[79] Zhang, Z. Zheng, and M.R.L., 2011. BFTCloud: A byzantine fault tolerance framework for voluntary-resource cloud computing. *In Cloud Computing (CLOUD), 2011 IEEE International Conference*, pp.444–451.

[80] Zhu, Dakai, Rami Melhem, and D.M., 2004. The effects of energy management on reliability in real-time embedded systems.". *IEEE/ACM International Conference on Computer Aided Design, ICCAD*. [1]

[81] Z. Tang, L. Qi, Z. Cheng, K. Li, S. U. Khan, and K. Li, "An Energy-Efficient Task Scheduling Algorithm in DVFS-enabled Cloud Environment," 2015.

[82] A. Najari, "Optimization of Dynamic Virtual Machine Consolidation in Cloud Computing Data Centers," vol. 7, no. 9, pp. 202–208, 2016.

[83] H. He and D. Liu, "Optimizing Data-Accessing Energy Consumption for Workflow Applications in Clouds," vol. 7, no. 3, pp. 37–48, 2014.

[84] Y. Liu, B. Gong, C. Xing, and Y. Jian, "A Virtual Machine Migration Strategy Based on Time Series Workload Prediction Using Cloud Model," vol. 2014, 2014.

