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An Energy Efficient Resource Monitor and Alert Model Using Cloud Computing

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Abstract: Cloud computing comprises layers of abstraction for availing resources to the customer with high reliability. The customer has to pay for the resource consumption, so they require cost efficient services. Cloud providers use the energy efficient resource method for keeping the resource with minimized cost. Traditionally the provider faces the problem of monitoring the resource and keeping the high available resources. This is handled by using a metric gateway which is used to collect the metrics and perform the analysis with the respective threshold. The proposed model uses a twofold approach 1) generating alert with threshold and 2) visualization. Metrics server keeps all metrics which are classified based on the resource level. The proposed model concentrates the energy metrics because of analysis of the resource with minimum threshold. Exporters act as middleware for identifying the metric values in the cloud. The main objective of the proposed model is to monitor the cloud resources using the alert mechanism for making the cloud service in a reliable and highly available manner. This model achieves 90% of reliability because of using various kinds of matrices in dynamic power management.

Keywords: *Alert model, Cloud Computing, Cloud Monitoring, Energy Aware Model, Virtual Machine.*

1. Introduction

Cloud computing is a computing model which provides any computer elements as a service by following service-oriented platform techniques. Web services model support the cloud for achieving the remote resource access via discovered services with consumption of all end users. Various levels of access and abstraction are maintained for making high available resource access. Cloud services are deployed in high level and capacity servers called data centers which consume energy. The energy of the data center comprises various factors such as infrastructure components, host and VM level elements etc. monitoring of these elements is a difficult task because of the involvement of the performance and reliability over the cloud services. The periodic monitoring process helps for the admin to make identification of the faulty element and services with description. The energy levels are monitored to maintain less consumption and also reduce the cost and enhance the lifetime of the cloud infrastructure. Data center energy is measured based on various factors like efficiency, minimizing the idle elements, virtualizing the server and its storage, server consolidation, power distribution at all levels. Metrics in the cloud supports analysing the system in a predictive manner and also determines the level of load and its provisioning. This is handled by imposing the rules and policies which are related to the particular condition while performing cloud related operations. Company uses the cloud metrics by identifying the key indicators related to the performance level. The IT company also defines their own metrics related to services that are maintained and deployed in the cloud. The indicators are categorized into various types namely time, cost, quality and so on. Alert plays the important role to notify the issues in the cloud services and infrastructures based on the specific interval of time. The proposed techniques generate alerts based on the energy metrics collected from the cloud data center.

The rest of the paper is organized as follows; Section 2 presents the related work of the proposed model. Section 3 represents the process of proposed energy model. Section 4 provides the analysis of energy matrices. Section 5 specifies the distribution of metrics of the proposed model. Section 6 presents the performance related metrics analysis. The result and discussion are specified in section 7 and finally section 8 focuses on the conclusion and future work.

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2. Related Work

Traditional mechanisms face a problem for verifying and satisfying the agreement established between the cloud providers because of static property. PRESENCE framework uses the agent for collecting and measuring the metrics in different intervals. It is suitable for Software components metrics but it is not suitable for data center bare metal elements in the cloud [1]. Cloud models are analysed based on the service factors such as integration, process delivery, process deployment in an automated manner. The metrics are visualized by creating the custom dashboard with logging and configuration management. Various environments are maintained by the IT Company with cloud support by identifying the bugs and irrelevant activities of the services [2]. Existing service framework does not provide the high quality because of the large number of metrics exposed by the deployed application.

The problem faced by the metrics model is to select suitable and correct metrics. The metrics are selected from the respective components source by performing the correlation among metrics [3]. QoS is affected due to the anomalies occurring in the cloud services and also degrades the performance of the cloud. These anomalies are detected by monitoring the cloud resources with respective metrics. The PerfInsight model collects the data automatically and removes the noise presented in the metrics data which will help to achieve high performance [4]. The Existing eBusiness model fails to provide a balance between cloud and business team. Integrated framework addressed this problem by using metric with feedback and goal-based approach. Three types of metrics are used for making the decision during the project handling process namely project and platform metrics, business and infrastructure metrics etc [5].

The metrics collected from on-premises differ from off-premises because the cloud deployment is migrated to other environments and supporting resources. It is monitored based on the static rules. Stack Insights model maintains three levels of stack namely application-level metrics, data level metrics and infrastructure level metrics with different workload [6]. Cloud services are establishing the contract which comprises various metrics used for monitoring the resources. Cloud metrics work with custom metrics because the applications are deployed in the cloud. Energy metrics are organized as an ontology in order to perform the task such as management and discovery process [7]. Monitoring rules validated by the customer is not efficient, so this problem is overcome by using a chat-based approach with keywords and constraints. This model also supports the native languages for performing correcting measures for metrics [8].

Software infrastructure needs a monitoring process because it suffers bottlenecks and failure problems. Two levels of monitoring are done over the cloud namely logical level and physical level with alerting and allocation of resources etc [9]. Cloud services are evaluated based on different factors but it doesn't involve formal definition, so it is addressed by using an efficient quality model. This model reduces the complexity present in the services while deploying into the cloud [10] [11] [12]. The existing methods are based on the metrics of various resources which involve fulfilling the customer requirement with high performance, but it suffers reliability and cost analysis. The proposed technique eliminates this problem by considering energy related response with three layered stacks with alerting system [17].

3. Proposed Energy Aware Model

Data center uses various metrics after deploying the application with relevant data. Different kinds of metrics are available namely native metrics and application metrics. Native metrics are related to the cloud infrastructure metrics based on the CPU Utilization, memory usage, energy consumption of various resources and so on. Energy consumption is a vital process in the cloud computing domain because all the resources consume energy which involves the cost. A resource consumes the energy in active as well as passive states. Active state is an energy consumption with workload whereas passive is an idle resource. Application-level metrics are exposed to the metric server for further processes related to performance. The proposed model ensures the energy level metrics are collected and generates alerts to the cloud administrator in case of any violations occurring during the infrastructure management. Three types of exporters are used for collecting the metrics from different levels such as VM, Host and Data Center. Data center exporter collects and exports the metrics like number of hosts and its energy consumption. Host and VM exporters also export the energy related metrics of host and VM respectively [18].

Two types of metrics collectors are present in cloud computing namely pull based and push based model. Pull based model is responsible for collecting the metrics from cloud infrastructures and push based model automatically pushes the respective metrics to the metric server. The proposed model uses the pull-based model and stores all the collected metrics to the database. [19] Normally specific metrics are used for the analysis, so the exploration process performed for energy related metrics. The alerts are generated to the cloud admin for taking necessary actions for protecting the resources which go to idle or crash state. The alert rules are prepared with a predefined threshold for all the resources. The energy threshold level is set for three layers of abstraction [20]. Once the threshold is reached the alert is automatically sent to the admin via email or slack. The visualization section generates the analysis of the resources with energy level with report and graphical form. The model representation of the proposed method is shown in figure 1.

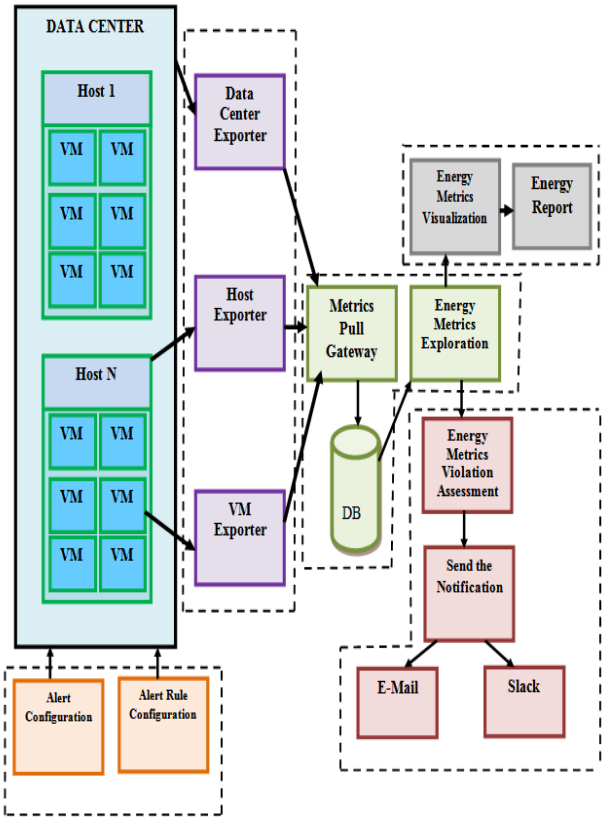

Figure.1 System model

4. Energy Metrics Analysis

Metrics in the cloud are categorized in various levels which are collected by the specific services and stored into the database or storage. Normally the metrics are stored into the local file system only, so it is erased whenever the resource terminates or restarts to the new state [21][22]. The persistent storage needs to support the metrics and related data in persistent state i.e. stable storage. The health of the VMs is monitored periodically for identifying the failure count and detailed information about those VM. It also checks the packets travelled in the internal network as well as the public network with its status. The database read and writes operations are also monitored based on the number of operations performed during a particular time. The energy metrics are collected and calculated from these metrics for reducing the consumption with cost in the cloud. Algorithm 1 shows the metrics with corresponding threshold for identifying the excess power which are consumed by the cloud resources.

Algorithm Alert_Metrics_Management()

```
Begin
LetVM_Metrics
={Snap_Time,VM_Data_Capacity,VM_Free_Memory,VM_Size}
Let
Host_Metrics={Power_State,CPU_Usage,Max_avail,Memory_Usage,Memory_MAx_Avail}
Let
DC_Metrics={energy_Infra_efficiency,IT_resource_Utilization,
corban_level}
Let VM Threshold as VMThres;
Let Exporter Metrics as EVM;
Let Energy metrics as VM_Energy;
For each metrics ε EVM do
L1: if ( exporter == VM_Exporter) then
      For each metrics ε VM_Metrics do
        If ( metrics.Instance>= VMThres) then
Goto L11;
       End
      if ( exporter == Host_Exporter) then
      For each metrics ε Host _Metrics do
        If ( metrics.Instance>= HostThres) then
        Goto L11;
       End
      if ( exporter == DC_Exporter) then
      For each metrics ε DC_Metrics do
        If ( metrics.Instance>= DCThres) then
Goto L11;
       End
End
L11:
        Generate alert to the admin via email;
        Take Corrective Action;
End
End
```

Cloudsim model is used for the energy analysis of the cloud with various metrics [23] [24]. Datacenter defines the number of hosts and VMs with the processing capability. The storage capacity is also defined for storing the energy metrics in order to analyze based on the reliability. Various types of power model are used in the cloudsim, namely linear based, square root based. Square based and cubic based. The proposed energy model uses the linear model because the resources are provisioned based on the customers workload.

The threshold limit is also related to the resource type, so that the admin is able to get the alert and locate the problems in the cloud resources and location. Latency matrix gives the detailed delay occurs across various regions which is in Table 1.

Bandwidth requirement and usage of different services are modelled using corresponding matrix is exposed in table 2. The CPU utilization of the VM is shown in Table 3. Minimum and maximum threshold is fixed in order to protect the resources from over utilized and underutilized conditions. These conditions consume irrelevant energy and lead to higher cost to the customer.

Table 1. Latency matrix

region	**1**	**2**	**3**	**4**	**5**	**6**
0	2000.0	1000.0	1000.0	1000.0	1000.0	1000.0
1	1000.0	800.0	1000.0	1000.0	1000.0	1000.0
2	1000.0	1000.0	2500.0	1000.0	1000.0	1000.0
3	1000.0	1000.0	1000.0	1500.0	1000.0	1000.0
4	1000.0	1000.0	1000.0	1000.0	500.0	1000.0
5	1000.0	1000.0	1000.0	1000.0	1000.0	2000.0

Table 2. Throughput matrix

Virtual Machine	**Minimum Threshold (%)**	**Maximum Threshold (%)**	**Average Resource Limit (%)**
VM1	7.105	7.285	9.2654
VM2	7.677	7.725	9.9799
VM3	53.095	53.943	53.687
VM4	4.78	5.28	5.04

Table 3. Threshold Comparison

region	**1**	**2**	**3**	**4**	**5**	**6**
0	25.0	100.0	150.0	250.0	250.0	100.0
1	100.0	25.0	250.0	500.0	350.0	200.0
2	150.0	250.0	25.0	150.0	150.0	200.0
3	250.0	500.0	150.0	25.0	500.0	500.0
4	250.0	350.0	150.0	500.0	25.0	500.0
5	100.0	200.0	200.0	500.0	500.0	25.0

5. Metric Distribution Analysis

The metrics of the cloud infrastructure is based on various perspectives namely service level, system level, request time, response time, reliability level, security level, scalability level, capacity level and bandwidth level and so on. Service-related metric analysis is calculated by taking the ratio between handling of request with active state with total number of estimated times for response. The component and its functional time are considered for system level analysis.

Reliability metrics are based on the time to failure and repair because it is directly related to the cost and customer satisfaction with quality. The response time of the cloud service is used to retain the customer and add more customers for achieving high demand across the competitors. The security related metrics are defined for ensuring and eliminating the security standard violation, network related attack and location. The enforcement of access control prevents the service and system level attacks by the outsiders.

Bandwidth metrics consist of the data centre transmission, web server bandwidth and network bandwidth because the fluctuation in the bandwidth leads to retention and reliability. The capacity of the cloud requires the workload for existing infrastructure. The metrics of this type directly involve the cost so the resource involvement for handling workload is properly monitored in order to minimize the expense. Latency metrics are calculated between the request packet count as well as response packet without any excess time. These metrics are necessary for making the cloud service with a high level of abstraction in the cloud.

The metrics distribution of the cloud is related to factors such as service, systems, security and bandwidth are modelled using a joint probability distribution model and find out the overall cloud metrics for further monitoring process. Service-related metrics are collected based on the customers and corresponding response as a service is represented in equation (1).

$$F\{Service\ Metrics(N1)\} = \int_0^n \frac{Customer^n \times Service^n}{N} dn \quad \textbf{(1)}$$

System metrics are measured by mapping the request to the cloud component by process the application data is presented in equation (2).

$$F\{System\ Metrics\ \ (N2)\} = \int_0^n \frac{\mathrm{Re}\,quest^n \times\ Component^n}{N} dn \quad \textbf{(2)}$$

The SLA violation by the attacker by imposing attacks to make the service unavailable or service crash is analyzed in equation (3).

$$F\{Security Metrics\ (N3)\} = \int_0^n \frac{SLA - Attacks^n}{N} dn \quad \textbf{(3)}$$

The throughput metrics are important for provide rapid response to the customer which assessed by considering the cloud region and its throughput is shown in equation (4).

$$F\{Bandwidth Metrics(N4)\} = \int_0^n \frac{\mathrm{Re}\,gion^n \times Throughput^n}{N} dn \quad \textbf{(4)}$$

The overall metrics of the cloud data centre is calculated by setting the threshold$^{\delta}$ in order to make the application access efficiently. Various metrics are simplified and achieves the precise result is shown in equation (5)

$$Overall Cloud\ Metrics = \frac{1}{N^2}[Cloud\ \ Service^{n+1}] \quad \textbf{(5)}$$

6. Analysis of Performance Metrics

The traditional way of handling software metrics is only project based as well as technical based which is not suitable for cloud-based application. This issue is addressed by a hybrid version of the technical model for evaluating the metrics and making effective decisions [13]. If real time workload is dependent on allocation of resources, balancing the load, rapid response which is not applied over a non-cloud environment. This platform is static and complex, so the metrics are represented in a common template in an automatic manner with proactive nature of service response [14]. Cloud services suffer the quality due to irrelevance in the standards and lack in the verification. Different types of applications are used in the cloud while deployment which expose a huge number of metrics so these metrics are selected in standard framework [15].

Cloud models use automated testing tools and high-end dashboards which comprises various metrics including platform as well as infrastructure. The application logs are collected by triggering the scripts and then generating the report [16]. The proposed model collects and configures the metrics which are suitable and necessary for the analysis and perform the action items by the respective administrator or owner of the cloud resource and application. The efficiency analysis is done using the pseudocode with various levels.

Pseudocode for PUE

If **PUE==3.0** then
    Efficiency = very inefficient
Else of **PUE==2.5** then
    Efficiency = inefficient
Else of **PUE==2.0** then
    Efficiency = average
Else of **PUE==1.5** then
    Efficiency = efficient
Else of **PUE==1.2** then
    Efficiency = very efficient

Power Usage effectiveness metrics gives the energy usage consumed by the data centre and also provides guideline for achieving higher efficiency. It is calculated by taking the ratio between total infrastructure energy and total availed power is in equation (6).

$$\text{Power Usage Effectiveness} = \frac{Total\ Availed\ Power}{Total\ Infrastructure\ Power} \quad \textbf{(6)}$$

DCiE is an efficiency metrics in the data centre for determining the overall efficiency in different regions which calculated by taking inverse of PUE. Equation 7 gives the DCiE metric formula

$$\text{DCiE} = \frac{1}{PUE} \quad \textbf{(7)}$$

Figure 2 provides the metrics comparison of DCiE realted to the PUE level. If the PUE value is high then the efficiency is low so keep the PUE metrics as small as possible.

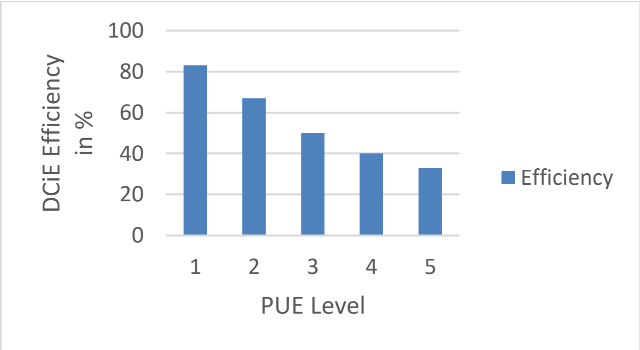

Figure 2. PUE Vs DCiE Analysis

7. Results & Discussion

The cloudsim simulation [17] [20] model is used for the proposed monitoring technique with high performance parameters. Initially the data centers are configured and then add the required host with various attributes. Xen hypervisor with migration support is used for handling VM with threshold levels. Host configuration uses 70% static power with 250 of maximum power. Linear power model is used for analysis based on the time shared VM scheduling policy. The utilization cost of the proposed model is 0.1 which is measure in MIPS, bandwidth and latency between the customer and provider is 1.5 and 0.5 respectively. Monitoring interval is 1 minute so that the reliability is maintained at the proper level. If the resource energy consumption crosses the threshold the alert will be generated and the action is taken by the administrator. The service violations done by the customers are identified by generating alerts to the provider for taking the optimal decision process. It also eliminates the rescheduling process as well as re negotiation process [25].

Hybrid algorithm uses the request in redundant with integration of the resources in a minimized way. This approach achieves 94% accuracy when compared to the existing model [26]. Figure 3 shows the energy consumption of various VM in the host in different time intervals. If the threshold is reached, it is alerted with the description.

The resource utilization of the data center is shown in figure 4. If there is any fluctuation in the resource level then the administrator gets the alerts and does the necessary action to bring the resource in up condition. These analyses are done based on the energy matrices acquired from the various resources in the cloud.

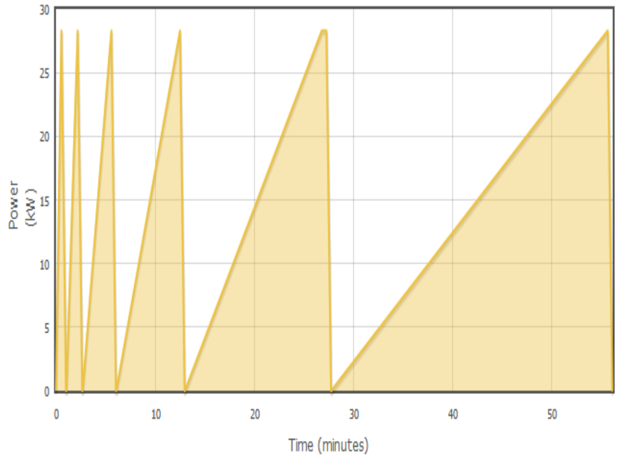

Figure 3. Power analysis of the data center

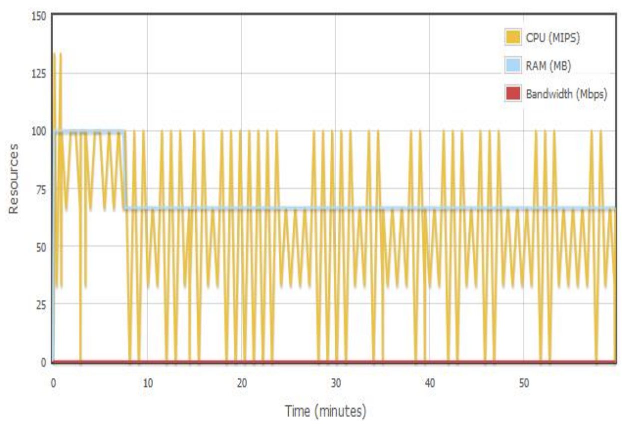

Figure 4. Resource utilization analysis

8. Conclusion & Future Work

Cloud monitoring process plays an important task in the real time application because the customer requires high available service without any failure. The admin maintains backup or alternative resources for handling the emergency situation. The cloud admin doesn't know about the problems and its corresponding resources with location. The alerting system helps to locate the resource and perform corrective action. Various monitoring models are available in the cloud but it monitors all metrics because not all metrics are used for analysis. This analysis needs the transforming of the metric value to the specific format which helps for further operation. The proposed model uses the energy level metric because of maintaining long running services. The alert also generated for intimate the causes of the problem with description. The main objective of the proposed work is to model the cloud in a highly reliable and efficient manner. According the result achieved by the proposed model is 90 % with minimum PUE value with is efficient when compared to existing models. In future, this model can be used for edge network monitoring with minimum risk.

Conflicts of Interest

The authors declare no conflict of interest in the preparation and publication of this work in this journal.

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