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CostEnergy Aware ModelForWorkflow Jobs in Heterogeneous Cloud

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Abstract

Cloud computing is an emerging technology that facilitates all the resources in an on-demand basis. The process of selecting, deploying and managing the hardware/software resources to ensure the application performance is defined as resource provisioning. In a heterogeneous cloud computing environment, various types of virtual machines are interconnected with each other to provide better computational capabilities. The main intention of this research work is toreduce the costfor work flow jobs by considering the total energy cost and load rate of the Virtual Machine in the cloud environment. The cost for the work flow jobs are reduced by reducing the execution time of the jobs .The reduction in the energy consumption would decrease the cost for execution of jobs .The main objective of this research work is to reduce the cost required for resource provisioning in cloudby reducing the energy consumption.

Keywords -Virtual Machine, Workflow jobs, Cloud Computing, Heterogeneous cloud,Idle Energy, Process Energy, Total Energy Cost.

I. Introduction

The commonly used computing techniques are grid computing, distributed computing, utility computing and cloud computing. In grid computing, the resources from multiple locations are collected to achieve the desired goal. The grid computing is also referred to as the distributed system with non-interactive workloads. In distributed computing, the components that are located in the networked computers communicate and coordinate with each other through message passing. In utility computing, the service provider provides the computing resources and infrastructure resources as per the cloud user expectation. On receiving a request from the cloud user for the computing resources and infrastructure resources, the cloud provider allocates the resources on the rental or metered basis.

Energy consumption in cloud is one of the major issues that need to be addressed. Even when the server runs a minimal workload, it consumes about 50% of the peak power, hence it is necessary to minimize the energy consumption. The reduction in the energy consumption would decrease the cost for execution of jobs. The consumption of energy is proportional to the workload of the application. Large data centers are essential for executing the large scale service applications. The large data center demands high energy cost.

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Cloud computing allows the individual users to have administrative access to a dedicated VM instance. In a heterogeneous computing environment, several machines are interconnected with each other in order to provide different computational capabilities. It is mainly used to achieve computational demands of large and diverse groups of jobs.

The workflow is described as a Directed Acyclic Graph (DAG). Here, the nodes are considered as the jobs and the edges are denoted as the job dependencies. The defining property of the scientific workflow is used to manage the data flow.The workflow scheduling is the process of mapping and managing the execution of the dependent jobs in the distributed resources. The workflow defines the automation of the business process during the transformation of jobs from one user to another user to perform a particular job based on some set of procedural rules.

The section II shows the related work based on the concept of Energy Aware model, Heterogeneous Cloud environment, Workflow jobs. The section III deals about the Workflow System.Section IV deals with the calculation of total energy cost. Section V deals with the comparison of proposed system with the already existing approach. Section VI describes the conclusion of this paper and future work related to this paper. Section VII deals with the various reference papers available in various journals.

II. Related work

This Section deals the related work based on the Energy Aware model, Heterogeneous Cloud environment,Workflow jobs.Qi, et al. [1] proposed a heterogeneity-aware dynamic capacity provisioning scheme named HARMONY to reduce the energy consumption of the cloud environment. The K-means clustering algorithm divided the workload that had the same resource and performance requirements into distinct task classes. When compared to the other state-of-art solutions, the Heterogeneity-Aware dynamic capacity provisioning scheme reduced the energy consumption by 28%. Zhang, et al. [2] proposed RESCUE, an ENERGY AWARE scheduler to reduce the energy consumption of the data centers in the heterogeneous cloud environments. Three benchmarks such as BS-seeker, Matrix Streesmark and TPC-W were used.Chuan-Sheng, et al. [3] introduced a component and direct acyclic graph based workflow design to enhance the scalability and the system's workflow based dynamic changes. In a workflow system, the workflow process was constructed from pre-arranged activities with certain specifications. The workflow instance was generated by a single iteration of the workflow execution.Yi, et al. [4] proposed change sequence mining approach for providing an automatic customized workflow. The suggested approach followed delete activity, Insert activity and move activity. By using the Apriority algorithm, the frequent item set was generated and the association rule was generated from the frequent item set. Sangho, et al.[5] proposed a cost-aware checkpointing and migration to provide reliable resources for lower cost. The

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checkpointing maintained the states of the applications as snapshots for restarting its execution at later time. Unnecessary checkpointing resulted in overhead and infrequent checkpoints increased the recovery time after the failure. Wang, et al. [6] suggested a model free approach for providing an effective resource allocation and energy management under varying workloads. The revenue of the service providers was increased through efficient resource allocation in the heterogeneous multi-tier cloud environment. The reduction in the energy consumption in turn reduced the operational cost.Panda, et al. [7] proposed a task scheduling algorithm for the multi-cloud environment. The virtual machines (VMs) by combining all the resources, satisfied the cloud users. Using the manager service, the status of the VM was monitored periodically.Panda, et al. [8] addressed the issues related to the scheduling workloads in the heterogeneous multi-cloud environment. Three task scheduling algorithms namely Mobile Cloud Computing (MCC), Cloud MAX-Min Scheduling (CMAXMS) and Cloud Min-Min Scheduling (CMMS) were proposed to maximize the cloud utilization and minimize the makespan.Buysse, et al. [9] proposed a routing and scheduling algorithm to minimize the energy consumption of the cloud without compromising the QOS.

The Routing and Scheduling algorithm reduced the energy consumption by switching off the unused resources.Wang, et al.[10] proposed a MapReduce based multi-object bi-level programming model to improve the energy efficiency of the cloud computing environment. The

Fig 1.1 Main Stages of WMS

proposed model focused on the server's energy efficiency affecting resources like memory, bandwidth.

III. Workflow system for heterogeneous cloud

The workflow system consists of a workflow engine, a resource broker and plug-ins for communication with different technological platforms. A Workflow Management System (WMS) is mainly used for the proper management of executing the workflow jobs. It is executed on the computing resources. Figure 1.1 shows the major stages of the WMS.

The workflow design mainly describes the composition and definition of the workflow components. The basic elements of the workflow design are workflow structure, workflow model and workflow composition system. The workflow structure mainly defines the relationship between the workflow jobs. In general, this structure is categorized into two types such as DAG and non DAG. It is also segregated into parallelism, sequence and the choice in the DAG based structure. If the job is executed in a series manner, then that is the sequence structure. After the successful execution of the previous job only, the new job gets ready for execution. If the jobs are executed in a concurrent

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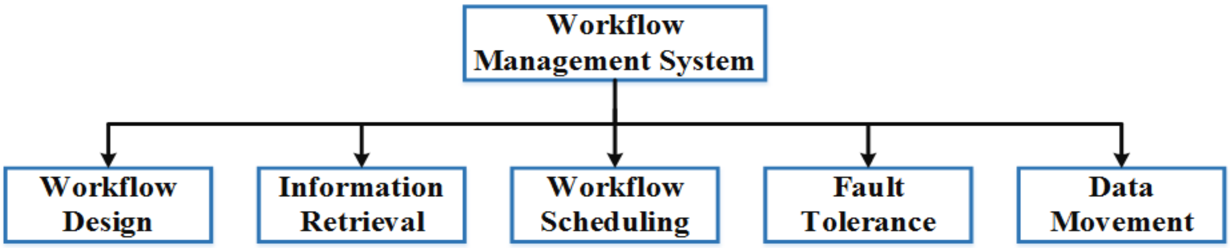

manner, then that structure is named as the parallelism structure. If the workflow is executed in both series and concurrent manner, then the job is named as the choice structure. The WMS is mainly used to describe the complex scientific procedures.It automates the data derivation processes.It uses high-performance computing to enhance the throughput and performance. It has persistence components such as provenance management and query.

Some of the existing WMS are Pegasus, Askalon, Taverna, Keplar and Triana. The cloud computing is used among researchers for scientific workflows to perform complex large scale data analysis and high throughput computation. The workflows enable the scientists to define the data, computational components and also their dependencies in an easy and declarative manner.

IV. Cost energy aware method for workflow jobs in heterogeneous cloud environment

This section describes the calculation of total energy costby considering Idle energy, process energy and load rate of Virtual Machine.

State of VM

In order to reduce the energy consumption of the VM, the state information of the VM is managed to provide better results. The state information of the VM is either in the form of ON mode or OFF mode. The ON mode is indicated as 1 and OFF mode is indicated as 0. The current value of the VM remains constant, but the variation in the reply of the VM depends on the value, which is added to the current value of the VM by the user. The current state of the VM in the proposed methodology is clearly tabulated in Table 1.1.

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Table 1.1 VM States

Current Value	Add Value	Reply
0	1	1
0	0	0
1	0	1
1	-1	0

Table 1.1 illustrates the states of the VM. The current value of the VM switches between 0 to 1. Here '0' denotes the OFF mode and '1' denotes the ON mode of the VM. To switch the VM from ON mode to OFF mode, -1 is added to +1. If the VM is to be maintained in the ON mode, 0 is added to 1. The changes in the state of the VM is estimated by using the following equation

$$y_{t+1}^{i} = y_t^i + u_t^i \in y\,\{0,1\} \&\& \, u\{-1\,,0\,,1\} \qquad \ldots \quad (1.1)$$

where, y_{t+1}^{i} indicates the future state of the ith VM. The future state is the sum of y_t^i and u_t^i. Here, y_t^i denotes the current state of the ithVM and u_t^i is the utilization status of the ith VM at time t. The value of y lies between 0 to 1. Also, the utilization status varies between -1 to 1.

The Scheduling Parameter (SP) value is computed for all VMs in the matched resource group by considering the following scheduling parameters.

1. ***Energy Cost***– It describes the cost of energy consumed by the resource during the job execution state as well as idle state.
2. ***Load Rate*** – It is defined as the length of the jobs or tasks.

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The scheduling parameters such as total energy cost and load rate are computed by using the following equations.

Cost of Idle Energy

The idle energy is defined as the energy level of the VM in the idle state while switching from one process to another process. When the VM is in the idle state, the equation below is used to estimate the cost of idle energy

$$E_t^{Idle} = U_p \sum_{i=0}^{M} \sum_{j=0}^{N} y_t^j \left(E_t^{Idle_i} \right) \qquad (1.2)$$

The idle energy for all the VMs is estimated based on the current state y_t^j of the ith VM during execution of jth job at the time t, energy level of the ith VM in the idle state $E_t^{Idle_i}$ and energy unit price U_p.

Cost of Process Energy

The process energy is defined as the energy level of the VM during the job execution state. When the VM is in the process state, then the cost of the process energy is estimated by using the following equation

$$E_t^{Process} = U_p \sum_{i=0}^{M} \sum_{j=0}^{N} \sum_{k=0}^{R} \alpha^{ik} + u_t^{jk} \qquad (1.3)$$

The process energy is calculated based on the energy unit priceU_p, computation time for current job α^{ik} of ithVM in kth resource group and utilization rate u_t^{jk} of ith VM in k^{th} resource group during execution of jth job.

Total Energy Cost

The total energy cost is the sum of the cost of idle energy and process energy of the VM. It is estimated as follows

$$E_t = E_t^{Idle} + E_t^{Process} \qquad (1.4)$$

E_t is the total energy cost of the VM. These parameters are directly proportional to the energy utilization in the process state. The utilization rate u_t^{jk} of the ith VM in k^{th} resource group during execution of jth job is computed by using the following equation

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$u_t^{jk} = \frac{\sum_{j=0}^{N} L_j^{ik}}{CS^{ik}}$(1.5) The utilization level is the ratio of the sum of length of all jobs in the i^{th} VM of k^{th} resource group to the computation speed of i^{th} VM in k^{th} resource group. The computation time for the current job is defined as the ratio of length of the job to the computation speed of i^{th}VM in k^{th} resource group.

$\alpha^{ik} = \frac{L}{CS^{ik}}$(1.6)

In the proposed work, total energy cost E_t is considered as the scheduling parameter value. Then, the job is allocated to the VM having minimum scheduling parameter value. Table 1.2 shows the symbols and descriptions used in the proposed model.

Table 1.2 Symbols and descriptions used in the proposed model

Symbols	Descriptions
P_1, P_2	Priority of the job
S_1, S_2	Size of the job
D_1, D_2	Demand of the job
y_{t+1}^{i}	Future state of i^{th} VM
y_t^{j}	Current state of i^{th} VM during execution of j^{th}job
u_t^{i}	Utilization status of i^{th} VM in time t
E_t^{Idle}	Cost of energy in the idle state at time t
U_p	Unit Price for Energy

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M	Number of VMs
N	Number of jobs
R	Number of resource groups
u_t^{jk}	Utilization rate of ith VM ofk^{th} resource group during execution of jth job
L_j^{ik}	Length of the jth job in ith VM of kth resource group
CS^{ik}	Computation speed of ith VM of kth resource group
α^{ik}	Computation time for current job
$E_t^{Process}$	Energy utilization cost in the process state of VM
E_t	Total energy cost of the VM

V.Performance analysis

Different simulators are available in the cloud computing environment for evaluating the performance of the proposed model. They are Cloudsim, WorkflowSim, CloudAnalyst, and EMUSIM. The proposed research methodology uses the Cloudsim and WorkflowSim simulator to evaluate the performance of the CEA(Cost Energy Aware) model.

Energy Utilization

Energy utilization is defined as the amount of energy required for resource provisioning in a heterogeneous cloud environment. Here, the energy utilization is calculated for 5 to 50 jobs. Table 1.3 presents the energy utilization analysis with the number of jobs for three models VCG, NAE and EANAE.

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Table 1.3 Energy utilization analysis

No. of Jobs	ENERGY UTILIZATION (J)		
	VCG	NAE	EANAE
5	127	86	56
10	149	97	67
15	158	106	71
20	175	111	78
25	186	130	82
30	191	141	85
35	199	147	91
40	205	160	95
45	215	164	103
50	225	178	119

Figure 1.2 depicts the energy utilization of the three models VCG, NAE, EANAE

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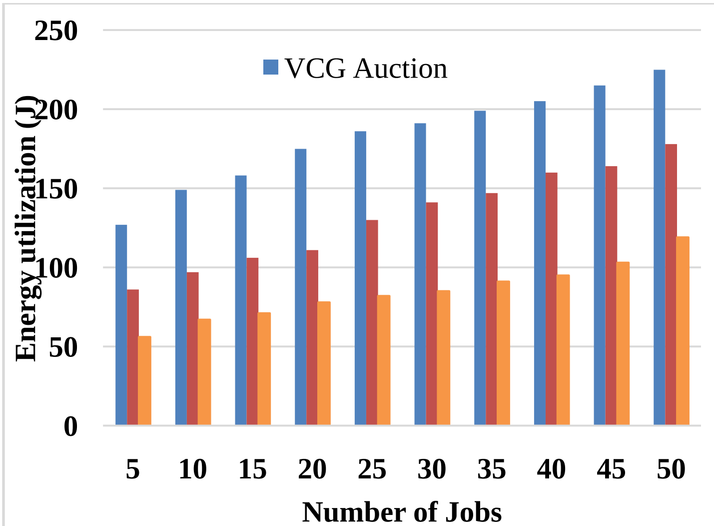

Figure 1.2 Energy utilization for VCG auction, proposed NAE and EANAE models

The VCG auction, NAE, EANAE models consume 127, 86 and 56 J for the execution of 5 jobs. If the number of jobs is increased to 50, then VCG, NAE, EANAE models consume 225, 178, 119 J respectively. The EANAE offers 55.90% and 34.88 % reduction in energy consumption for minimum number of jobs (5) compared to VCG and NAE models respectively. Similarly, for maximum number of jobs (50) it offers 47.11 and 33.15 % reduction in energy consumption. The proposed CEA model further reduces the energy utilization for number of jobs as in Table 1.4.

Here, 5 to 50 jobs are taken to calculate the energy consumption of EANAE and CEANE models. Table 1.4 presents the detailed analysis of energy consumption for number of jobs for EANAE and CEANE models.

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Table 1.4 Energy utilization with number of jobs

No. of Jobs	ENERGY UTILIZATION (J)	
	EANAE	CEA
5	56	49
10	67	59
15	71	68
20	78	71
25	82	77
30	85	81
35	91	86
40	95	90
45	103	98
50	119	103

The proposed CEA model consumes 103 J for 50 jobs which is 13.44 % less than EANAE. Similarly, for 5 jobs the CEA consumes 49 J which is 12.5 % lesser energy utilization than EANAE.

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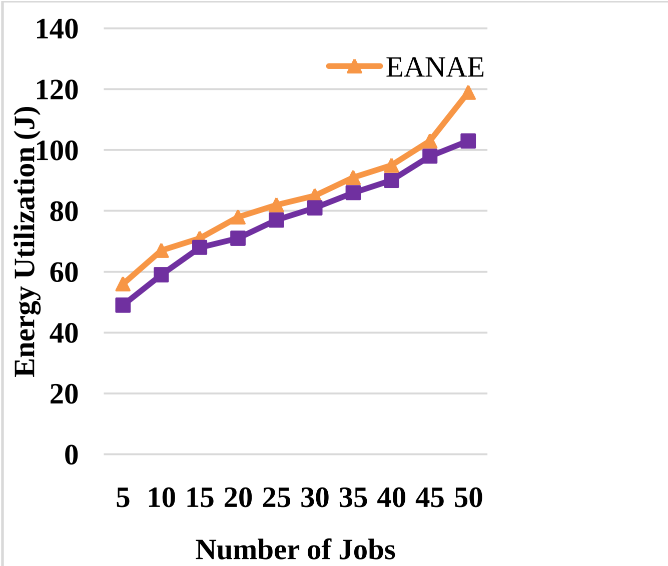

Figure 1.3 Energy consumption for EANAE and CEA models

VI. Conclusion and future work

Cloud computing is one of the major emerging technologies that provides various services to users.The main objective of this research work is to minimize the total energy cost during resource allocation. The suggested CEA(Cost Energy Aware) model estimates the total energy cost by using the factors such as Idle Energy, Process Energy and load rate of the matched resource.The reduction in the energy consumption would decrease the cost for execution of jobs.

By avoiding the allocation of jobs to the mismatched resources, the scheduling delay is minimized. Once the job fails, the job is reallocated to another VM that has the same resource type, minimal energy cost and load rate. The proposed methodology enhances the system reliability and minimizes the total energy cost, number of failures and execution time.. Further, the network bandwidth and geographical location of the VMs can be considered for an effective resource provisioning in cloud.

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