Study of Energy Efficient Algorithms for Cloud Computing based on Virtual Machine Migration Techniques

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Abstract

Green cloud is a catchphrase in today's IT industry. Due to the wide acceptibility of cloud,the industry is being inclined towards cloud application and the high demand of performance requirement in cloud leaves a question mark on energy consumption by cloud data centers. Hence energy efficiency in cloud computing is one of the most significant parameters to follow nowadays to evaluate the efficiency of the cloud service. It is a driving force for adaptability of a cloud computing service in recent era. For a highly commercial service like cloud, maintaining the QoS parameters and keeping the service availability and service quality highly optimized to get the competitive advantage, cloud data centers are almost available on a 24x7 basis ; which in turn is a reson for high power consumption. So it is very much necessary to maintain a balance between power and quality of the service. One feasible solution for achieving energy efficiency is Virtual Machine migration technique in real time or when they are in turned off condition. This paper discusses about several VM Migration techniques and analyses their perspectives.

Keywords

1. Introduction

Green cloud is an emerging practicing technology by todays developers and service providers, which reduces the power consumption as well as environment friendly[1].By adopting the new approach the cloud providers are not only being cautious towards the environment, but also they are saving their cost using energy efficient algorithm by reducing power consumption and also making a balance between energy saving and keeping quality of service as per the expectation of their client as well.

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At present large-scale data center comprises thousands of computer nodes. These data center devours huge amount of electric power and a big cause for CO2 emission to environment[2,4]. Cloud applications are installed in remote data centers, where large capacity servers and storage systems are being maintained. A fast growth of demand for cloud based services fallouts into establishment of massive data centers consuming very high amount of power. To protect this, energy efficient models are required, especially for complete infrastructure to decrease functional costs while preserving vital Quality of Service (QoS)[4]

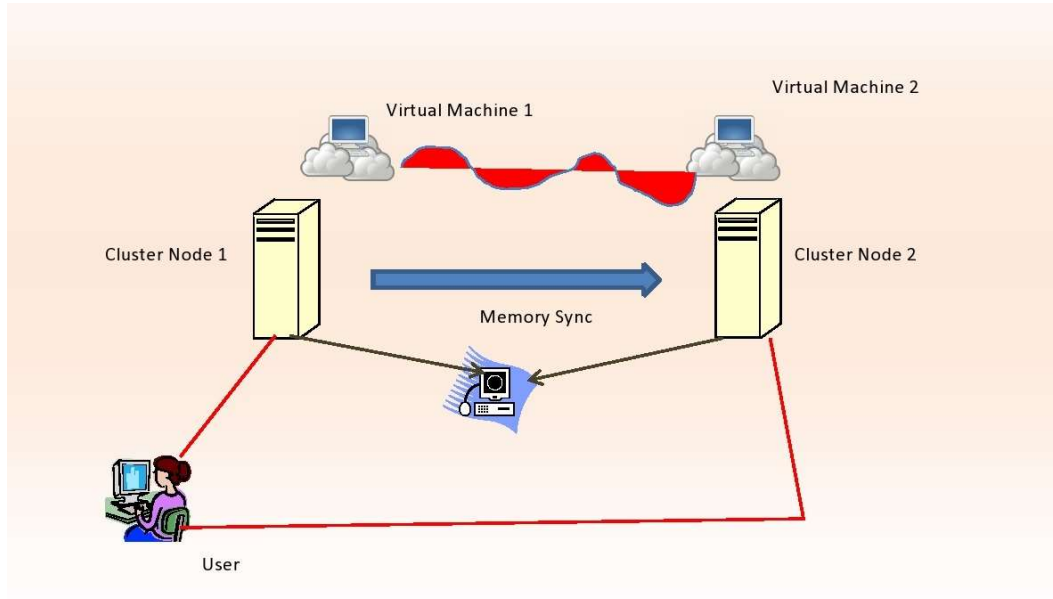## 1.1. Virtual Machine Migration Techniques: What, Why , When

Fig. 1: Live VM Migration

1.2. Types of Virtual Machine Migration

Hot VM Migration - you can transfer an active or running virtual machine to a different host/ server , or you can interchange its disks or files to another data store without any interruption in the obtainability of the virtual machine. This is also known as "live migration"[12]. This technique also follows two different mechanisms- pre-copy memory migration and post copy memory migration.
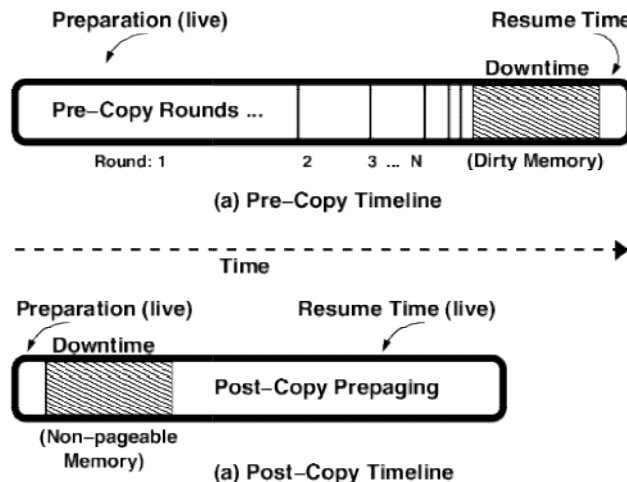

Fig. 2 :Pre- Copy Vs. Post Copy VM Live Migration(https://www.researchgate.net/figure/The-timeline-of-a-Pre-copy-vs-b-Post-copy-migration_fig1_221137806)

In case of pre-copy migration the Hypervisor copies the memory pages from source to the destination folder in the turned on condition , i.e. when the VM is in the still running . If some of the memory pages change during this process, they will be re-copied until they cover the bad copying rate[15].

Cold Migration – In this technique, a powered off condition or deferred virtual machine is being moved to a new host. Additionally, you can reposition the disk files for turned off or suspended virtual machines and move them to new storage locations. In case of cold migration process, virtual machines can be repositioned from one datacenter to another easily . To perform a cold migration, virtual machines can be moved manually or a scheduled task is set up.[12,16]

In VM data center you can have the following relocation options [12]

Table 1: Different types of relocation option for VM Migration

Change Host	Only relocate a virtual machine, but do not relocate it's storage to the destination host. You can move the virtual machine by using either cold or hot migration. One can also use vMotiontechnique to move a turned-on virtual machine to another host.
Change Data store	Moving a virtual machine along with it's storage, including the virtual disks and configuration files or a combination of these, to a new data center may be another process of VM migration. This also can be done by applying hot or cold migration techniques . One can use Storage Migration to move a running or turned-on virtual machine and its storage to a new data store.
Change Host and Data store	Moving a virtual machine to a destination host and moving its disk or virtual machine folder to another data store. One can change the host and data store using cold or hot migration. With vMotion technique also , the VM can be migrated to a new host and data store also simultaneously in environments without any shared storage

1.3 Type of VM Migration algorithm

VM Migration algorithms may be broadly categorized into three different segments :

Heuristic Algorithm– In such algorithms the set of constraints are problem dependent and deliver solutions to a problem in a restricted time. Most of the algorithms under such category are greedy algorithms.Several researchers re working in heuristic algorithm development for live VM migration.Abdullah, M., Lu, K., Wieder, P(2017) works on dynamic VM consolidation using a heuristic approach. The researchers have proposed a best fit algorithm for intelligent VM allocation and they have also proposed the dynamic utilization rate[19]. Where as some other group of researchers used heuristic approach to solve virtual machine scheduling prolem[20]. There are works on location selection policy to solve the overloading problem of virtual machines using this heuristic approach.

Meta Heuristic algorithms– They are mainly general purpose algorithms and nature inspired. VM Migration algorithms based on Ant colony optimization,particle swarm optimization or bee colony optimization, queen bee optimization falls under such category.A survey has been made upon several meta heuristic algorithms for virtual machine scheduling[21]. Genetic evolutionary approach, load balance oriented meta heuristic algorithm, genetic approach combined with knapsack problem there are seversal dimensions of meta heuristic approaches for VM migration process.

Hybrid Algorithms- A combination of heuristic and meta heuristic algorithms

2. Motivation of the Study

Cloud , being the fastest growing technology in this present technological era, faces the problem of energy efficiency.Cloud data center is a shared pool of computing as well as communication resources[17]. Due to highly competitive environment in this sector each and every service provider wants to satisfy their customers with a highly optimized service having 24 x 7 service availability, high storage, optimized level of multi tenancy and virtualization etc. But while meeting the QoS factors without any compromise, most of the cloud providers have to invest a lot in terms of power consumption in data centers also [2-4]. An idle server consumes 70% of the peak power[11] and hence leads to major energy efficiency . So today researchers have started work on this not only to protect the environment but also make their service more economic also[4].Green cloud revolution has started very recently.Green cloud computing not only limited to energy consumption but also concerned about reducing the E waste[17]. A survey has been made by the authors to enlighten the scopes and challenges in this area. (Singh N & Dhir V.,2017). Some researchers (Banerjee A. et. Al ,2013)   have proposed energy efficient models[3] . Some problems have been solved by linear regression method or other statistical methods , others have preferred working on hardware level . While performing hardware level operations for making it more energy efficient, DVFS is one such hardware based algorithm along with live VM migration(Patel V & Bheda H., 2014). The other relevant works can be found in some other papers (Forsman et al., 2015; Sun et al., 2016; López-Pireset al., 2018; Maleklooet al., 2018

From the study of various migration techniques , it indicates a direction towards the migration of Virtual machine to be one of the most popular load balancing techniques or popular energy efficient algorithm for reducing power consumption while maintaining the QoS parameters . VM Migration algorithm includes constraints and equalities in the algorithm as valid conditions[9]

3. Study of Several VM Migration Techniques

In present era several researchers doing researches on virtual machine migration techniques. Banerjee A. et al(2013), in their paper have discussed about several energy efficient tools that are already available in the industry and they also discussed about various dimension of energy consumption while maintaining the QoS of the cloud service, which is actually a big challenge[4] . Among those techniques energy aware resource scheduling, cluster based energy conservation protocols. The paper is based on generic approach and the authors also proposed an energy efficient scheduling method based on hyper graph and its matrix representation. But the implementation section is not highlighted in this paper[4].

Singh N &Dhir V.(2017) have conducted a survey on several VM Migration techniques which can be helpful to get a clear view about the present trend and future direction of energy efficient cloud algorithms [3].This has created a pathway for the cloud researchers in this arena.

One feasible solution for VM Migration technique has been proposed by Patel V &Bheda H.(May, 2014) by using DVFS technique for making energy efficiency for real time data in cloud data centers. The authors have introduced the hardware based Dynamic Voltage Frequency Scaling (DVFS) concept for live VM migration. This papers proposes a technique by adjusting the system voltage based on CPU utilization[13]. When the workload is more, real time migration can be provided for effective usage of resources.

By applying this technology, without the requirement of restarting the power supply, system voltage and frequency can be adjusted in accord with the specification of the actual CPU design into a dissimilar working voltage. While CPU works in lower voltage, the energy consumption can successfully be saved. Here the solution can be achieved by CPU utilization

monitoring but for an overloaded CPU when the numbers of VMs are nearer to maximum , then this solution faces some criticality to achieve the expected result.

Huang, C. J. &et. Al, (2013) in their work have discussed about adaptive resource scheduling for cloud computing to make it more energy efficient [2]. A genetic algorithm based resource dispatched technique has been proposed in this paper. This paper discusses about energy efficiency as well as QoS guaranty.

Deshai R. M & Patel B. H (April,2015) have discusses about energy efficient algorithm using virtual machine migration[15]. The authors have proposed a characteristic based compression technique for VM migration. Their proposal follows a good path to solve overloaded resources but it takes a long time for migration which creates problem in maintaining QoS of cloud service as most of the cloud service providers promise in their Service Level Agreement(SLA)[15].Deshpandey U. and Keahey K.(2017) has proposed a live VM Migration technique which is traffic sensitive[8]. In their study the authors have adapted an approach which reduces the contention between the migration technique and the traffic load.

Raval N and ThakkarR(2016) has performed a survey among existing VM migration techniques. The authors have performed there study regarding several compression techniques and their optimizability and working procedure. The authors have proposed a characteristics based algorithms using Run Length Encoding.

Table 2: Comparative study of papers on energy efficient algorithms for VM Migration (selected)

Paper Title	Authors' Name	Journal/ Conference Name(With volume and Issue, if available	Main approach	Remarks
Efficient VM Migration technique for energy reduction in cloud computing	Singh N &Dhir V	International Journal of Advanced Research in Computer Science, volume 8, issue 9	Survey among several VM migration techniques for energy efficiency in cloud computing	Give insights about several techniques used
Energy Efficiency Model for cloudComputing	Banerjee A. et al	International Journal of Energy, Information and CommunicationsVol.4, Issue 6	Energy aware resource schedule and cluster based energy conservation protocols	Various dimensions of energy consumptions along with QoS parameters performance intact.But lack in the implementation area
An adaptive resource management scheme in cloud computing	Huang, C. J. & et. al	Engineering Applications of Artificial Intelligence, 26(1)	Adaptive Resource scheduling algorithm of cloud computing	Provided AI included solution
Dynamic virtual machine consolidation for improving energy	Deng, D., He, K., & Chen, Y	.Cloud Computing and Intelligence Systems	Reducing energy consumption and SLA violation	QoS parameter is not well maintained

efficiency in cloud data centers				
Efficient Virtual Machine Migration in Cloud Computing	Desai R. M & Patel B. H	Fifth International Conference on Communication Systems and Network Technologies	Characteristics based compression algo for reducing total migration time along with total downtime	Too much dependent on defined characteristics
Reducing Energy Consumption with Dvfs for Real-Time Services in Cloud Computing	Hitesh Bera	IOSR Journal of Computer Engineering	Using DVFS based live migration technique to to increase efficiency of energy management in real time	Hardware dependent and complex architecture to manage
Reducing VM Migration Time By Compression Algorithm And Setting Threshold Of Dirty Page Rate	Raval M and Thakkar R.	International Journal of Innovative Research in Technology	The paper discusses about different VM Migration categories and a characteristics based algorithm along with memory compression technique has been proposed	

The approach of VM Migration based on Dynamic Voltage scaling(DVFS) may be applied using CPU Monitoring and it is primarily dependent on hardware resources . The main approachof such techniques is to decline the CPU voltage(V) and frequency(F) to reduce the power consumption(P) according to the following formulae :

$$P = V^2 * F * C \qquad\qquad Equation\ 1$$

In the above formula Power consumption(P) is dependent upon Voltage level(V), Frequency(F) and Capacity of the system(C).

$$V_{CPU} = \frac{MIPS(VM)}{MIPS(HOST)} \qquad\qquad Equation\ 2$$

$$Utilization\ of\ CPU = \sum_{i=1}^{n} V_{CPU}/MIPS(HOST) \quad Equation\ 3$$

But this process may generate some voltage drop due to CPU frequency reduction as well as generating high overhead. So this may not be very effective techniques for VM Migration in real time.

4. Conclusions and Future Direction

This study discusses about energy efficient cloud computing algorithms, energy consumption requirement by cloud computing and among other several solutions , live Virtual Machine migration technique as a very effective solution. Through this study the authors has tried to focus on heuristic, meta heuristic as well as hybrid approach of live VM migration algorithms.

In conventional cloud data centers power consumption was in its highest level, in such cases,specially when the system has an overload, virtual machine migration technique may be effectively applied. One of the significant challenges of the VM migrationtechnique is the time required to migrate the VM from one data center to other. Storage reallocation is also another challenge for VM Migration. Though there are plenty of research works in this area , still it leaves ample scope for the researchers to generate feasible and optimized solutions. The new paradigm shift is being directed from cloud towards fog computing and also the use of predictive modelling for VM migration leaes a huge scope for exploring this area.

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6. Authors' Biography

Dr. Santanu Kumar Sen, received BE(CSE), M.Tech (CSE), MBA (IS) and PhD(Engg.) from REC Silchar and Jadavpur University respectively. He is a Fellow of IET(UK), IE(I), IETE(I) and Sr. Member of IEEE (USA), CSI(I) and life members of ISTE. Presently he is working as Professor and Principal in Gurunanak Institute of Technology. He has around 25 years of experience in the field of Computer Science and Engineering in which 8 years in Industry and 17 years in Engineering Academia including Abroad.

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Dr. Rajib Bag was born in 1969, received hisB.Sc (Physics Hons.) from Calcutta University, M.Sc. (Physics) from VinobaBhave University and M.Tech. &Ph.D (Engg.) from Jadavpur University, India in the year of 1991, 1996, 2007 & 2012 respectively. His doctoral work was in the field of control systems. Presently, he is working as a Professor & Head in the department of Computer Science & Engineering at Supreme Knowledge Foundation Group of Institutions under MaulanaAbulKalam Azad University of Technology, West Bengal, India. He has more than 40 publications in reputed refereed journals and conference proceedings to his credit. Presently five research scholars are doing their research work in different areas under his supervision. His research interest includes image and signal processing, education technology , machine learning, deep learning and IOT security besides control systems.

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