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Competitive analysis of Energy aware VW Migration Algorithms in Cloud Computing

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Abstract

The concept of Cloud Computing was first propounded by John Mc Cathy way back in 1961, wherein he envisaged the idea of computer time sharing technology. Efficient utilization of computing resources to reduce energy consumption in cloud computing is also a crucial issue because it decides the operational cost. Energy consumption of Cloud Computing has been a major concern of many researchers, and one of the reasons for huge energy consumption of Clouds lies in the inefficient utilization of computing resources. In this paper we perform Competitive Analysis of existing Energy Aware VM Migration Algorithms in Cloud Computing. This objective paper is to provide a comprehensive and comparative understanding of existing literature and aid researchers by providing an insight for potential future enhancements. Multi tenancy, concurrency and distribution are main feature of any cloud computing architecture. This paper covers different Vm Migration Algorithms for energy reduction in cloud computing (Heuristic ,Meta-heuristic& Hybrid algorithms) along with other novel techniques. The main plus point of heuristic algorithms is that they give satisfactory solution one.

Keywords: Cloud Computing; VM Migration; Genetic algorithm; VM Placement Algorithms; Virtual Machine

Introduction

Cloud computing has revolutionized the Information and Communication Technology (ICT) industry by enabling on-demand provisioning of elastic computing resources on a pay-as-you-go basis. Cloud computing is very much beneficial for small to medium organization. SME (Small to medium enterprise) can save on up-font cost by outsourcing its computational needs to cloud provider and consequently costs of maintenance and upgrades. Second option is to build private cloud within organization to boost effective resource management and resource provisioning.

Today large-scale data center contains thousands of computer nodes. These data center consumes huge amount of electric power and CO2 (carbon dioxide) emission to environment. Given the increasing focus on reducing energy use, ASHRAE (American Society of Heating, Refrigerating and Air- Conditioning Engineers) recently created Standard 90.4-2016, "Energy Standard for Data Centers" (Form http://www.achrnews.com accessed on 17-3-2017)

Need of Study: Gartner Says Global IT Spending to Reach $3.7 Trillion in 2018 (Form https://www.gartner.com/newsroom/id/3845563 accessed on 4-1-2018.) Latest technologies like cloud computing, blockchain and or electric autonomous vehicles or IoT, big data, DAPP,5G putting more and more pressure on grids in data center that results in increased energy consumption (Webina, 2018)

The only drawback with cloud computing is that it is a notorious power guzzlers and call for a stringent 'energy efficiency' regime (Sigh N., Bal J.S.,2017) Currently it is estimated that servers consume 0.5% of the world's total electricity usage. Server energy demand doubles every 4-6 years. With their enormous appetite for energy, today's data centers emit as much carbon dioxide as all of Argentina; Data center emissions are expected to quadruple by 2020 (Kaplan J. M., Forrest W., and Kindler N, 2017)

Between 2000 and 2007, the total power consumption of data centers worldwide went from 70 billion to 330 billion kWh; it's projected to grow to more than 1,000 billion kWh by 2020. In 2003, the power density of a single rack of servers was between 250 W and 1.5 kW. In 2014, it had reached almost 10 kW and is projected to reach up to 30 kW by 2020. Apart from low ROI, energy consumption has a significant impact on carbon dioxide (CO2) emissions, which are estimated to be 2% of global emissions (Buyya R., Beloglazov A., and Abawajy J., 2010)

"In the actual scenario, with an average Power Usage Efficiency (PUE) of 1.8, worldwide data center energy consumption will reach 507.9 TWh by 2020", explains Mattin Grao Txapartegy, Technology & Market Analyst at Yole.

Figure 1 Worldwide Data Center Facilities (Form http://www.yole.fr accessed on 17-03-2018.)

Energy facts about Data Center: Currently it is estimated that servers consume 0.5% of the world's total electricity usage. Server energy demand doubles every 4-6 years. With their enormous appetite for energy, today's data centers emit as much carbon dioxide as all of Argentina. Data center emissions are expected to quadruple by 2020. The average data center consumes as much energy as 25,000 households. Between 2000 and 2007, the total power consumption of datacenters worldwide went from 70 billion to 330 billion kWh; it's projected to grow to more than 1,000 billion kWh by 2020.In 2003, the power density of a single rack of servers was between 250 W and 1.5Kw.

Table 1: Worldwide IT Spending Forecast (Billions of U.S. Dollars) Source: Gartner (January 2018) (Form https://www.gartner.com/newsroom/id/3845563 accessed on 4-1-2018.)

	2017 Spending	2017 Growth (%)	2018 Spending	2018 Growth (%)	2019 Spending	2019 Growth (%)
Data Center Systems	178	4.4	179	0.6	179	-0.2
Enterprise Software	355	8.9	389	9.5	421	8.4
Devices	667	5.7	704	5.6	710	0.9
IT Services	933	4.3	985	5.5	1,030	4.6
Communications Services	1,393	1.3	1,427	2.4	1,443	1.1
Overall IT	**3,527**	**3.8**	**3,683**	**4.5**	**3,784**	**2.7**

In 2014, it had reached almost 10 kW and is projected to reach up to 30 kW by 2020. It is reported that the energy consumed in data centers is about 1.5% of the global electricity in 2010, and the percentage will be doubled by 2020 if the current trends continue (Koomey J., 2011)

One of the ways to address the energy inefficiency is to leverage the capabilities of the virtualization technology (Xen and the art of virtualization, 2013) An idle server can consume a lot of energy but storage and networking equipment while doing nothing consumes a very little energy. A sitting idle consumes 70% of energy & producing heat; Cost of running a server in a public sector data center is 14000 euro in Europe it includes the energy, maintenance, licensing cost etc. Utilization of server in vast majority of data center ranges from 15% to 25% in which they do useful work rest is waste (Webinar: 2018)

Problems of High Power and Energy Consumption in Cloud Computing: To understand the problem of high power consumption, it is necessary to understand the terminology. An electric current is the flow of electric charge. Electric current is measured in amperes. Power or energy can be defined as work performed by system. Power is defined as rate at which computer system executes the work. Energy is defined as amount of work executed in a period of time. Power/energy is measured in watts or Killo watt-hour.

Power = work executed /unit time.

Energy = power * unit time.

Objectives of Research

1.To study Competitive analysis of Energy aware VW Migration Algorithms in Cloud Computing

Literature Review

It is necessary to understand difference between power consumption and energy consumption. Power consumption can be diminished by decreasing CPU performance but in this case an application may take more time to complete its execution using same amount of energy. Electricity cost/bills can be reduced through diminishing energy consumption. Technique such as DPM (Dynamic Power Management) or SPM (Static Power Management) can be used to reduce energy consumption. DPM uses real-time resource usage statics & VM workloads to improve on energy consumption. SPM suggest use of modern highly energy efficient H/W components such as CPU, disk storage & network devices etc.

Static & Dynamic Power Consumption: Complementary metal-oxide-semiconductor (CMOS) circuits consumed major part of static & dynamic power. Static power also known as leakage power can be defined as leakage of currents in active circuits, power wasted because of leakage depends on type of transistors & technology used in computer system. Any reduction in static power consumption requires improvement in hardware level computer system design; therefore, it is not within the scope of this thesis. DPC (Dynamic Power Consumption) depends upon circuit activity & usage, clock rate & input- output activity. DPC is generated by short circuit currents & switched capacitance. SPC (Static Power Consumption) accounts for 10 to 15% of total DPC & there is no way to reduce this without compromising the performance. A very popular DPM technique called DVFS (Dynamic voltage & frequency scaling. In DVFS is performed by adjusting supply voltage & clock frequency as per need. The central idea is to reduce CPU performance when it is underutilized by adjusting the voltage and frequency of the CPU. This way we can achieve reduction in DPC. DVFS is supported by all kind of modern servers.

The State of Art in Energy Efficient Computing System: Power management techniques can be broadly classified into static & dynamic techniques. Static Power Management (SPM) techniques consist of all the methods and improvements that are used during designing & manufacturing of the circuit, architecture or system to improve the performance of computer system. It is can be achieved by making improvement in hardware level design of transistors, gates and circuits. In this chapter I shall discuss Dynamic Power Management (DPM) techniques & illustrates how system adapts to changing resource requirements. DPM techniques can be applied at hardware or software level.

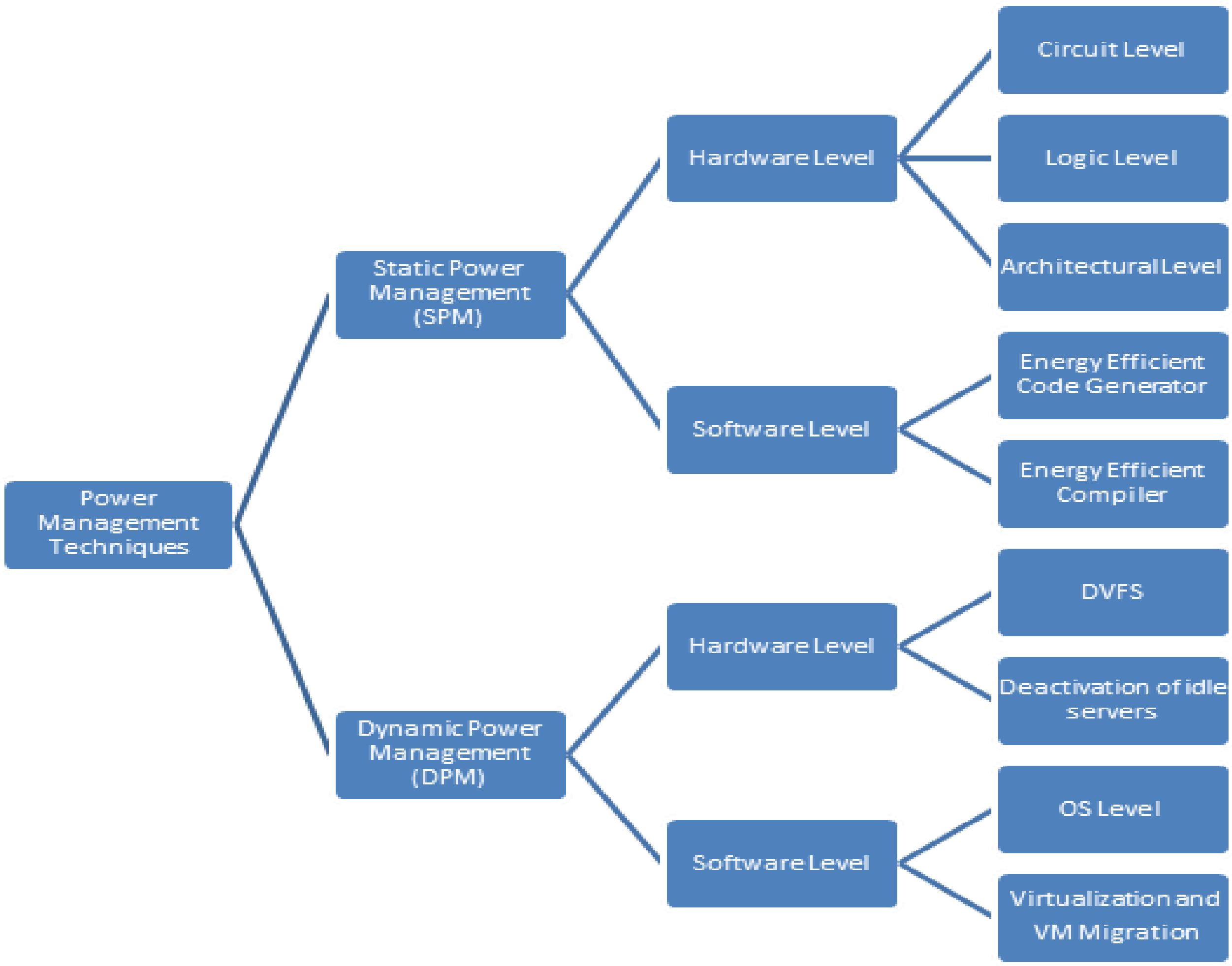

Figure 2 A High-Level Taxonomy of Power and Energy Management

Hardware DPM can be divided into two categories as Dynamic Performance Scaling (DPS) and DCD (Dynamic Component Deactivation), e.g. DVFS. DCD can be further classified as Partial or Complete DCD that can be applied during period of inactivity. Software DPM uses an interface to apply power management techniques to hardware.

Table 2 Competitive Analysis of Energy Aware VM Migration Algorithms in Cloud Computing :

Scheme(Ref.)	Description	Performance Improvement
VRDI (WEN et al.(WEN Y., LI Z., JIN S., LIN C., LIU Z. 2017)	Virtual resource dynamic integration (VRDI) method is based on the live migration technology of VM, which can reduce the energy consumption of a data center by integrating the virtual resources.	i) The VRDI method can save about 45% of energy when the resource utilization of PM is less than 50%. (ii)SLA violation of the VRDI method is lower than that of the BMH and ACS-VMC methods. (iii) the number of VMs to be migrated in the VRDI method is larger than the BMH and ACS-VMC methods.
ECR (WANG et al. (Wang S, Qian Z, Yuan J, You, 2017)	New task model that describes the QoS requirements of tasks with the minimum frequency. Used energy consumption ratio	i) OECR (energy-aware method Optimal Energy Consumption Ratio) can save more than 15%
	(ECR) to evaluate the efficiency of different frequencies under which to execute a take.	energy as compared to FFD algorithm.
Self-organized criticality Approach (Laredo et al. (Laredo J.L.J., Guinand F.,Olivier D., Bouvry P)	Self-organized criticality approach for dynamically load-balancing computational workloads. This approach is able to converge towards near-optimal trade-offs where the energetic efficiency and the QoS are maximized.	Minimizes the energy consumption (i.e., number of active resources through time) and maximizing the QoS (i.e., the average waiting time of tasks in the system
Dynamic overbooking strategy (Son et al. Son J., Dastjerdi A.V.,	By using dynamic overbooking strategy, they proposed dynamic overbooking algorithms (Conn Cons +Most Corr and Conn Dist + Least Corr).	Performs better as compared to baseline algorithms No Over and Conn None) in terms of

Calheiros RN, Buyya R,2017		energy consumption and SLA violation.
NSGA-II (ZHENG et al. 2017)	Non-dominated sorting genetic algorithm (NSGA-II) and a local selection strategy based on fuzzy is used to generate a Hybrid Energy-Aware Resource Allocation Approach in Cloud Manufacturing Environment	Minimizes the energy consumption as compared to base line algorithm.
Multiagent (MA)-based VMallocation approach (Wang et al. [16])	MA works by first dispatching a cooperative agent to each PM to assist the PM in managing VM resources efficiently.	Compared with traditional centralized bin packing-based BFD approach, MA performs better in terms of energy & migration cost.

Performance Evaluation Approaches: In this section, we will discuss some cloud efficiency matrices and simulation toolkits that have been used for VM migration performance evaluation The green grid (https://www.thegreengrid.org/ accessed on 17-3-2019) has suggested some matrices that allow us to calculate energy consumption of data center. This section explains cloud efficiency matrices & methods that are used worldwide

Power Usage Effectiveness (PUE)

PUE was purposed by Green Grid (a non-profit organization of IT professionals) in 2007. PUE is accepted as industry standard for reporting the energy efficiency of data center.

The PUE is defined as follows:

PUE = Total Facility Energy/IT Equipment Energy

IT equipment energy means the energy consumed by all the IT equipment (e.g. compute, storage & network equipment) and supplement equipment (e.g. KVM switches monitors & laptops).Total facility energy means energy consumed by all IT equipment plus energy consumed by supporting system such as Cooling system components such as cooling towers & computer room air conditioning units (CRACs).Power delivery components such as UPS systems, power distribution units (PDUs), generators & energy lost in conversions AC to DC. Data center Lighting, energy consumed by lighting equipment's in a data center. Higher PUE value means that most of data center energy is consumed in cooling measure instead of computing. A perfect PUE of a data center can be 1.0, which is impossible to archive. In reality most of sites have PUE ranges from 1.5 to 2.5 if they follow all green grid guidelines. The higher the PUE value is the lower the efficiency of the facility as more "overhead" energy is consumed for powering the electrical load (Form https://www.thegreengrid.org/). For example Google data centers have claimed that their data centers have achieved Quarterly PUE 1.10 & Trailing twelve-month (TTM) PUE 1.11 fleet-wide in 2018. (Source Google data center)

Partial PUE (pPUE) enables a data center administrator to focus on energy efficiency of a particular potion of data center.

Partial PUE (pPUE) = total energy inside a boundary/ the IT equipment energy inside the boundary

Data Center Infrastructure Efficiency (DCiE) DCiE is reciprocal of PUE. It is defined as follows:

DCiE = 1/PUE = IT Equipment Energy/ Total Facility Energy * 100

PUE and DCiE are really the same metric, but PUE has been widely accepted by major vendors because it is inherently simple & easy to implement.

Data Center Productivity (DCP)

DCP is a natural evolution from PUE and DCiE. DCP is defined as follows:

Data center Productivity = Useful Work/Total Facility Power

DCP is much more difficult to determine. What a data center's "useful work" constitutes is still an open issue so it is difficult to calculate.

Data Center Energy Productivity (DCEP)

Data center energy productivity is a sophisticated metric. It is defined as follows: DCEP = Useful Work Produced / Total Data Center Energy Consumed over time As compared to PUE, DCEP takes a more holistic approach.

Corporate Average Data center Efficiency (CADE)

Uptime Institute (an American professional services organization focused on improving the performance, efficiency, and reliability of business critical infrastructure through innovation, collaboration, and independent certifications, New York, US) and McKinsey's (McKinsey & Company is a worldwide management consulting firm, US) introduced Corporate Average Data center Efficiency (CADE) standard.

Research Methodology

This study is to provide a comprehensive and comparative understanding of existing literature and aid researchers by providing an insight for potential future enhancements. Multi tenancy, concurrency and distribution are main feature of any cloud computing architecture. This paper covers different Vm Migration Algorithms for energy reduction in cloud computing (Heuristic ,Meta-heuristic& Hybrid algorithms)

Research Results

Competitive analysis of Energy aware VW Migration Algorithms in Cloud Computing Found that

1. It defined as follows

CADE= Facility Efficiency * IT Asset Efficiency

Facility Efficiency= Facility Energy Efficiency Percentage * Facility Utilization Percentage IT Asset Efficiency = IT Utilization Percentage * IT Energy Efficiency Percentage

But neither CADE nor Data Center Productivity caught on the way the PUE standard has taken hold. Because of its inherent simplicity of PUE.

JouleX's Performance per Watt (PPW)

JouleX (a software company in Atlanta, USA that specializes in monitoring and control of the power consumption of computers and associated devices attached to networks) introduced Performance per Watt (PPW) metric. This approach uses a relative performance indicator (PI) for each individual asset. This indicator is calculated by the types of hardware and capabilities learned from an asset inventory of that device.

2. It defined as follows

PPW= (PI * Average Device Utilization / Watts) * 100

The PPW metric calculates the actual energy efficiency of every device in the data center and how it is used. Lower value of PPW indicates that device is wasting power. Higher value of PPW indicates device is at maximum utilization.

Cloud Simulators: Cloud simulation tools allows users to test their services in repeatable and controlled environment free of cost, it helps users to fine tune their applications before deploying on real clouds.

Table 2: Summary of Cloud Simulation Software

Simulator	Available	Programming Language	Energy Model	Description
CloudSim	Open Source	Java	Yes	Modular & extensible open- source simulator, simulate behaviour of large data center
CloudAnalyst	Open Source	Java	Yes	Support evaluation of social networks tools according to geographic distribution of users and data centers.
GreenCloud	Open Source	C++,Otcel	Yes	Packet-level simulator for energy-aware cloud
				computing with a focus on cloud communication.
MDCsim	Commercial	Java/C++	Rough	Discrete event simulator
iCanCloud	Open Source	C++	No	Designed to predict the trade-offs between cost and performance of a given set of applications that runs on cloud
Network Cloud Sim	Open Source	Java	Yes	Supports communication between application elements and various network elements.

EMUSIM	Open Source	Java	Yes	Provides both the capabilities of an emulator as well as simulator of a cloud environment.

Discussion of Research Results

Multi tenancy, concurrency and distribution are main feature of any cloud computing architecture. This paper covers different Vm Migration Algorithms for energy reduction in cloud computing (Heuristic ,Meta-heuristic& Hybrid algorithms) along with other novel techniques. The main plus point of heuristic algorithms is that they give satisfactory solution to a problem in limited time cost frame. Heuristic algorithms are easier to implement in comparison to meta-heuristic algorithms. In Hybrid algorithms, heuristic algorithms are used to provide initial VM placement and meta-heuristic algorithms provides optimum placement of VMs during migration. This algorithm increases the implementation complexity but reduces time and cost space. Depending upon the kind of problem, you can use one or other. In present work, Hybrid approach based resource provisioning and load balancing framework for workflows execution has been proposed to optimize the utilization of VMs with uniform load distribution. The proposed framework is based on the hybridization of heuristic techniques with metaheuristic algorithm to achieve its optimal performance in terms of makespan and cost. Two hybrid approaches have been proposed for HDD-PLB framework-Hybrid Predict Earliest Finish Time (PEFT) Heuristic with Ant Colony Optimization (ACO) metaheuristic (HPA) and Hybrid Heterogeneous Earliest Finish Time (HEFT) heuristic with ACO (HHA). The two proposed approaches for load balancing have been analyzed and compared to determine which is superior for proposed HDD-PLB framework. In proposed HDD-PLB framework, scientific workflows has been taken as input for execution. The workflows executed in proposed framework are from different application domains like gravitational physics, biology and astronomy. A few scientific workflows have been available for access to their code and data (Bharathi et al., 2008).

Suggestions

This Research Competitive analysis of Energy aware VW Migration Algorithms in Cloud Computing find that Vm Migration Algorithms for energy reduction in cloud computing (Heuristic ,Meta-heuristic& Hybrid algorithms) In this extension study, alternative alternatives should be applied to this research. It will cause benefits in the application.

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