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Improvement in Energy Efficiency Using VM Placement in Cloud Computing

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Abstract: *Cloud data centers provide computing infrastructure as a service to their customers on pay per use basis. In virtualized data centers CPU, RAM, storage and bandwidth are allotted to a Virtual Machine (VM) from pool of shared resources. An autonomic consolidation of VMs on appropriate Physical Machine (PM) by achieving performance and saving cost is the key challenge for virtualized data centers. In this paper, we propose an energy efficient algorithm for autonomic consolidation of VMs. The proposed algorithm does the initial placement of VMs in appropriate PM of cloud data centre which addresses different issues altogether such as maximum resource requirement during setup of VMs, future demand of free resources at peak load, improving the performance and energy saving by keeping idle PMs at offline state. The performance of the proposed algorithm is evaluated by simulating a data center with randomly generated resource capacities of PMs and resource requirement of VMs. Experiment results of proposed technique are also compared with standard algorithms of VM consolidation.*

***Keywords: Cloud computing, CPU, Physical Machine, Virtualization, Datacenter*.**

1. Introduction

Cloud Computing is a new distributed computing paradigm for dynamic provisioning of computing services on demand over the internet. Cloud computing is evolving as everything as a service on the internet. Cloud providers utilize one or more data centers to host cloud services and resources. These data centers can be distributed geographically to safeguard data availability. The growth in hyper-scale cloud data centers is one of the major contributors for the increase in electricity consumption across the globe. In the year 2014, US data centers consumed nearly 70 billion kWh of power which is approximately 2 percent of total power consumption of US [1]. Data Center Usage Report given by the U.S. Department of Energy stated that there is 4 percent increase in energy consumption of data center from 2010 to 2014. It is expected to continue with 4 percent increase during 2014-2020, and US data centers are projected to consume approximately 73 billion kWh of power in 2020 [1]. Efficient use of energy in data centers is a challenging task.

The 2010 energy efficiency scenario [1] show 's that there were nearly 100 billion kWh of energy saving from 2010-2014 and 520 billion kWh of energy saving is expected with current trends from 2015-2020. The major part of these energy savings comes from servers and infrastructures. Further, the energy consumption in data centers can be reduced by efficient use of servers in data centers, that can be achieved by efficiently placing virtual machines on servers and switching off the unused servers. Green cloud computing requires energy efficient use of data centers with minimum impact on environment [2]. There are several green metrics [3] defined to achieve greenness in data centers. A system is considered green when it consumes minimum energy to another system with the same goal. Green computing in the cloud can be achieved by implementing efficient policies and methods for energy aware resource management in virtualized data centers [4], [5]. The importance of dynamic VM placement is intensified by the high-power consumption of data centers. The placement of Virtual Machines over physical hosts became a vital component of any cloud management framework. While provisioning resources to VMs, it is important to maximize resource utilization by using minimum number of physical hosts.

2. Related Work

There are two focuses on VM placement problem for reducing energy consumption. One is to consider how to place VM in accordance with the physical server resources. Verma et al. [6] dynamically re-adjust server's location and consider the cost of application migration and energy, with a simple algorithm; it shows that dynamic migration technology realizes low energy cost.

Bobroff et al. [7] adopt prediction techniques while minimizing the number of active PMs, and present mechanism for dynamic migration of VMs based on a workload forecast. Cardosa et al. [8] reset max, min, share and other VM parameters to meet users' demands and to provide a new PM resource allocation method; it consolidates multiple VM onto PM to improve resource utilization and reduce power consumption. Wang et al. [9] consider the consolidation of VM bandwidth with PM bandwidth as a stochastic packing NP-hard problem, it shows certain size of VM is loaded onto a PM with a probability distribution, and the goal of optimization is to minimize PM number. However, only consider PM optimization, and ignore other resource. The PM optimizing schemes above either consider CPU constraints [6] or PM bandwidth constraints [6], and they neglect network topology and VM communication traffic. The other type [9-12] is to consider how to place VM to optimize network resources. Meng et al. [13] are to improve the network scalability in data center network with a traffic aware VM placement scheme. By optimizing VM's location in the PM host, the traffic between VMs is related to the network physical distance, and VMs with large traffic can be placed on PMs nearby to reduce the total network traffic. Mann et al. [11] are to reduce energy consumption by VM migration technology and network routing optimization. Such solutions only assume to meet physical servers needs. Fang et al. [14] are to optimize both VM placement and traffic now routing so as to turn off as many unneeded network elements as possible for power saving, and [8-10] only optimize network resources and neglect physical server resource optimization. Currently, some studies consider application performance when placing VMs, and the similar studies are in [14-16]. Jiang et al. [17] attempt to improve physical node utilization with VM placement, and to optimize the network link utilization by changing flow routing, but they do not optimize total traffic in data center network, so their objective is different from our scheme. Gupta et al. [18] address application-aware allocation of n VM instances to physical hosts from a single pool, which meets SLA requirements, and at the same time, improves the utilization of hardware resources. However, they do not consider network MLU in data center. Beloglazov et al. [19] propose a novel-adaptive heuristics for dynamic consolidation of VMs based on an analysis of historical data from the resource usage by VMs. Although this proposed algorithms significantly reduces the energy consumption while ensuring a high level of adherence to the SLA, it does not optimize network resource, so it is also different from our objective.

3. Energy Efficient Approaches in Cloud Computing

Green cloud computing model focusing on usage of internet computing services from source or provider that have considerations on measures to reduce the negative effect on environment. Improving the power usage efficiency, Usage of hardware with long lifespan Avoidance of toxic material on hardware components, Utilization of renewable energy resources and recycling of waste heat are some measures to make a green service. Various techniques like DVFS, virtual machine migration and virtual machine consolidation. Dynamic Voltage Frequency Scaling (DVFS) is a technique reducing dynamic power consumption by dynamically adjusting voltage and frequency of a processing unit. Virtual machine consolidation combining workload from various machines to a limited number of systems which increases the performance of a single physical machine whereas migration will transfer running virtual machine to another active physical machine. Both aim on reduction of power usage by the datacentre.

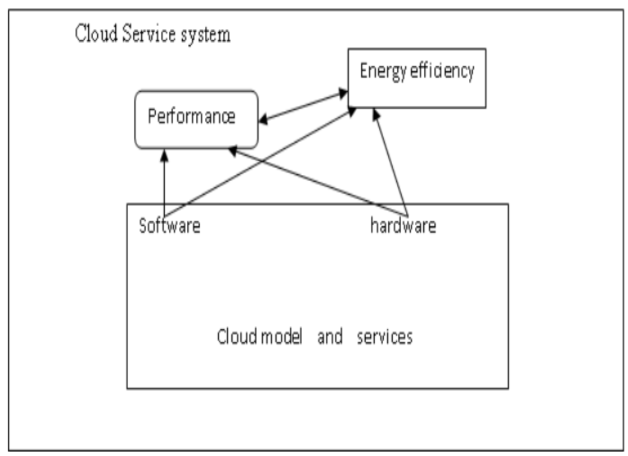

Figure 1. Cloud service systems

Software development, testing deployment and operations are also factors that affect energy efficiency. Both hardware and software in life cycle play important role in energy efficiency. In the software section energy is not only consume by the CPU cycle it also has role on storage section and data transfer section. To estimate energy consumption of program statements and structure we have to consider certain things which includes

- Complex operations and data structure consume more energy than their simple one.
- Task which increases CPU utilization and decrease CPU idle time reduce energy consumption

Task which prefers to use high performance storage has less energy consumption At present all data centre providers are focusing on an architecture with carbon footprint and looking towards a renewable resource with minimal emission of green gas.

4. Energy Usage

Green cloud computing is focusing to include environment friendly production system, energy efficient technology and efficient recycling management.

- Green at design
  Have to concentrate on design part itself for reduced energy consumption. Designing of server, infrastructure, digital devices, software applications have role to reduce energy consumption
- Green at production
  Recycling the equipment and optimized software application development can contribute positive effect on sustainable environment.

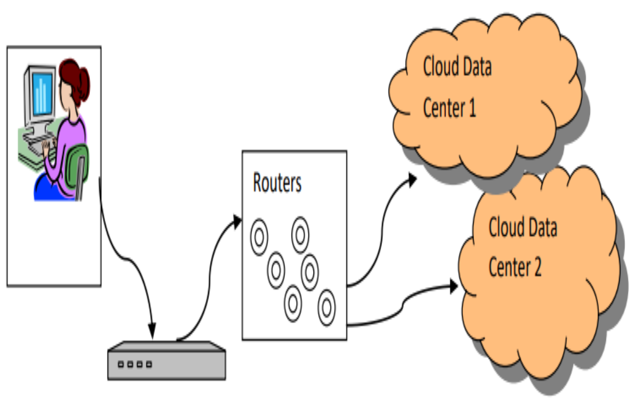

Figure 2. Energy consumption using cloud computing

User
First factor is user, how the software applications are designed and implemented. In cloud architecture we can run applications of individual user or the applications of cloud service provider. Both are utilizing SaaS and in both case energy consumption depends on the application. The inefficiencies of application like suboptimal algorithm improper usage of shared resources lead to increased CPU usage which leads to high energy consumption.

Network Devices
Another area which has contribution on total power consumption is network devices. Before the datacentre process, data traveling through many devices like Ethernet switches, broadband gateways, routers etc. Energy efficiency of network devices mostly depends on topology, system and protocol design.

Data Centres
Due to large number of equipment datacentres consume large amount of energy and emit mass amount of carbon. In the cloud infrastructure not only server and storage system consume energy but also the cooling devices consume equivalent amount of energy as the IT systems..

5. SunSystems v6.3

The Language Pack forSunSystems v6.3 includes a Language Deployer and all the languages available at that time. You must use the latest Language Pack available on the Infor Product Download Centre. Updated Language Packs are only released when language related changes are made in a patch set or new languages become available.
The Language Deployer:

- Populates the domain and security databases with the required language entries
- Pnstalls language dependent files
- Edits language configuration files automatically

Can be run on a multi-tier or multi-database installation, or on a standalone installation..

6. Proposed Methodology

6.1 Service Models

Infrastructure as a Service (IaaS)
Infrastructure as a service (IaaS) refers to online services that provide high-level APIs used to dereference various low-level details of underlying network infrastructure like physical computing resources, location, data partitioning, scaling, security, backup etc. A hypervisor, such as Xen, Oracle Virtual Box, Oracle VM, KVM, VMware ESX/ESXi, or Hyper-V, LXD, runs the virtual machines as guests. Pools of hypervisors within the cloud operational system can support large numbers of virtual machines and the ability to scale services up and down according to customers' varying requirements. [25] The capability provided to the consumer is the provision of grids or clusters or virtualized servers, processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems. The highest profile example is Amazon's Elastic Compute Cloud (EC2) and Simple Storage Service, but IBM and other traditional IT vendors are also offering services, as is telecom-and-more provider Verizon Business [20-24].

Platform as a Service (PaaS)
Cloud computing has evolved to include platforms for building and running custom web-based applications, a concept known as Platform-as-a- Service. PaaS is an outgrowth of the SaaS application delivery model. [26]

The PaaS model makes all of the facilities required to support the complete life cycle of building and delivering web applications and services entirely available from the Internet, all with no software downloads or installation for developers, IT managers, or end users. Examples include Microsoft's Azure and Salesforce's Force.com.

Software as a Service (SaaS)

The traditional model of software distribution, in which software is purchased for and installed on personal computers, sometimes referred to as Software-as-a-Product. [26] Software-as-a-Service is a software distribution model in which applications are hosted by a vendor or service provider and made available to customers over a network, typically the Internet. SaaS is becoming an increasingly prevalent delivery model as underlying technologies that support web services and service-oriented architecture (SOA) mature and new developmental approaches become popular. SaaS is also often associated with a pay-as-you-go subscription licensing model. Mean-while, broadband service has become increasingly available to support user access from more areas around the world. [27] SaaS is a software distribution model in which applications are hosted by a vendor or service provider and made available to customers over a network, typically the internet. Examples include G Suite - formerly Google Apps- Microsoft Office 365, Salesforce and Workday. In the Software as a Service (SaaS) approach, applications are delivered over the Internet in the form of service. Rather than installing and maintaining the software, one simply needs to access the software over the Internet.

Any SaaS model should have the following key characteristics:

- Multitenant Architecture – In a multitenant architecture, multiple users and applications share a common source code. This source code is maintained centrally in one location.
- Customization – Since the source code is maintained in a single place, it becomes easier to customize the application based on the business needs of the customer. SaaS is designed and organized in such a fashion that these customizations can easily be managed and maintained per customer.
- Accessibility – SaaS provides better access to data over the Internet. This makes it easier to manage privileges or monitor data usage. It also ensures that same information is available to all users at any point of time.

6.2 Understand the business requirements

Irrespective of the technology or the model, it is very important to have a clear understanding of the business requirements. Without this, we won't be able to design and develop any system or application. [28] In order to achieve better results, it is important to identify the goals and objectives at a very early stage. The investigation and discovery process should be robust enough to set the goals and directives at a very early stage. The investigation process should determine the following:

- How should the application be designed to run?
- What are the different categories of users who will access the application?
- How should the application respond to:
  - Scalability
  - Security
  - Failover issues

It is very important to identify and understand the characteristics of the application at a very early stage. Not only that, we should pay equal attention to identifying the challenges that the existing application, system or the process is facing.

Identify the team to take on the task

Again, irrespective of the technology or the model, it is very important that the team assigned to take on the task is well versed in the technology and the concepts. In the SaaS model we should have a team comprised of seasoned developers who understand the concept of SaaS in depth. The team should have members who have the expertise of multiple technologies and also should be well aware of the best practices that are followed in the industry. Design a scalable infrastructure Once the team has the complete understanding of the business requirements, the next step is to build the infrastructure along with the following components:

- Data canter
- Network infrastructure – connectivity and security
- Hardware – both systems and storage
- Backup and monitoring tools

[29] On top of these, there should be internal reviews to evaluate the cost-benefit-related issues while building the infrastructure. While finalizing decisions on infrastructure, one must take the following into consideration:

- Service level agreement (SLA)
- Scalability, availability and other performance factors
- Customer support and incident reporting
- Disaster recovery
- Network bandwidth
- Security management

6.3 Finalize the bandwidth requirement and hosting facility

It is very important that the infrastructure is hosted within a facility which has a public connectivity and maintains consistency to ensure positive user experience. While reviewing the bandwidth, we must think of the demographics of our application, e.g. the connectivity factor for a user sitting in an office where high bandwidth network speed is available would be different from a user who is connecting from home. It is also important that we place the infrastructure as close as possible to ensure fewer network hops. We should have multiple network connections to our data canter, thus eliminating network bottlenecks. If we decide to outsource the data canter infrastructure, we should consider the following:

- Is the data canter available 24×7×365?
- Testing frequency
- Availability of redundant systems for power and other hardware failures
- Physical security of the campus

Procuring the infrastructure components Once the infrastructure design is complete, we need to use components which have proven reliability and functionality. This step is critical in order to ensure high availability. While evaluating these hardware components, we must also ensure that the selected hardware is delivered within the timelines of our business needs.

6.4 Deployment of the SaaS delivery infrastructure

Once the infrastructure components are available, the operation team should start building and deploying the SaaS components. Servers should be racked, configured and subsequently the operating systems should be installed as per the need. Security devices should be upgraded with the latest versions of IDS. The firewall should also be configured as per the user access policy of the business.

Plan for disaster recovery and continuity
Now that the application is ready to be used over the SaaS platform, we must plan for disaster recovery and ensure continuity of the application. The following questions need to be answered in this regard:

- How do we respond to a disaster condition?
- How do we bring back the application in a limited time frame?

Integration of a monitoring solution A monitoring subsystem is vital. It helps to ensure timely intervention and avoid disasters. The system monitoring should be done based on the following parameters:

- Memory and CPU usages
- Event logs from the operating system and the application
- Different application components (TCP layer, database, application servers, etc.)

Prepare the customer support call centre Once the application is out on the market, it must have a customer support call canter. The call centre should be well connected and equipped to manage an appropriate ticketing system. [29]Customer support is a key component to ensure success of any model or application irrespective of the technology. The ticketing system should be enabled with an appropriate emailing system; if any issue requires the attention of the

Prepare the service level agreement (SLA)
An SLA must be in place while implementing the SaaS model. The SLA should clearly define the turnaround time and the response time along with the application availability.

Documentation
Once all of the above steps are completed, the entire infrastructure and its components must be documented. This document will help others to handle any exceptional behaviour of the application. It will also help if there are any modifications or alterations required in the infrastructure.

Virtualization and Software Delivery [20]
Virtualization encompasses various computing technologies and can be achieved both at the hardware level and at the software level. In an enterprise, virtualization can enhance the ability of software services, especially SaaS applications. It's also the most effective way for enterprises to reduce their IT costs. The concept of virtualization has been rightly adopted and accepted in the software development community. It has the ability to provide faster development and test mechanisms by creating development and test environments rapidly. [21] VMware and Virtual-Box are the most widely used technology, and they enable multiple users to run on different operating systems, versions and instances. Most software development enterprises adopt the virtualization technique by first adopting the software virtualization mechanism and then gradually moving toward hardware virtualization.

Virtualization and SaaS
In spite of having so many advantages, SaaS has many more helpful factors. These include:

- Huge Start-Up Cost: The revenue invested in the setup is recovered over a period of years.
- It May Violate the Principles of Free Software: [24]

Software freedom activist Richard Stallman refers to SaaS as "service as a software substitute (SaaSS)," and considers it a violation of the principles of free software. [24]"With SaaS, the users do not have a copy of the executable file: it is on the server, where the users can't see or touch it. Thus it is impossible for them to ascertain what it really does, and impossible to change it. SaaS inherently gives the server operator the power to change the software in use, or the users' data being operated on," Stallman wrote on the GNU website. A good example of SaaS over virtualization is Amazon Web Services (AWS). AWS offers a host of software and platforms. The software is installed on virtual hosts and can be scaled up or down as and when required. If we focus beyond the infrastructure and start-up cost, once deployed, an SaaS application platform should only be concerned with reproducibility. Each and every instance of the SaaS-based application should be identical to each other. There should be minimal differences in order to maintain the consistent behaviour of every application instance for each customer and for the support team. This is done so that they have a uniform base in order to troubleshoot any issue, if required. The support engineer would not like to discover a problem caused by a missing library module for a single customer instance. Similarly, neither would a customer like to know that there could be a problem in each application ordered because the SaaS-based company cannot reproduce the issue using the same steps for every order. The entire process should be automated for consistency and cost benefits.

Increasing complexity

It becomes important to understand the complex nature of deployment for today's applications be it the SaaS model or traditional model. Even the simplest Web application is no longer responsible for managing the underlying data storage layer. The standard practice is to have a database, for example, MySQL, Oracle, DB2 or SQL Server. Combining these with typical Web stacks such as Java, Ninja, Grails, Rails, etc., leads to a multi- tiered architecture demanding scalable deployment. For example, while setting up a Rails environment, we used MySQL. The agile nature of applications, which allows for easy upgrades of the software via plugins, patches, macros and mashups, can easily be integrated into the SaaS model. An extension or a patch is developed for a smaller issue, most of the time a bug fix, which needs to be delivered as a patch on the exiting software. Usually a customer wouldn’t like to hear that a problem occurred due to a resource constraint or some other circumstances, or that it is created by another customer. As per Wikipedia, separation of concerns is the premise to breaking down an application into distinct features, which minimizes functionality overlap. With virtualization in place, this concept can be applied to the infrastructure. Separation can be applied down to the per-application, per-customer, and/or per cluster basis. While still using the hardware to its maximum capacity, it provides the ability to scale horizontally and vertically. This is beneficial for single-tenant applications that wish to enter the SaaS market.

SaaS Security Concerns

SaaS, sometimes referred to as on-demand software, is a model where software is licensed on a subscription basis and is centrally hosted. [30] Hackers are increasingly interested in not only breaking into your network but the value of the data they may find there. If the SaaS provider is compromised, data encryption is a good idea to help protect organizational data; however, it will not protect against phishing and malware attacks launched to steal individual user access credentials. [24] Encryption should be considered a “must have” technology; but organizations should remember that it, by itself, is not a vulnerable. [24] The following is a brief listing of the top 10 security issues (by OWASP) that your SaaS offering should address:

1. SQL, operating system or LDAP injection
2. Insecure authentication and session management
3. Cross-site scripting because of lack of data validation
4. Insecure exposure to references like files and directories
5. Incorrectly configured (from a security perspective) databases, middleware and operating systems
6. Exposing sensitive data like user IDs, passwords and personal identification information Checking for access inside the business logic on the server side
7. Cross-site request forgery
8. Using components with known vulnerabilities
9. Un-validated redirects and forwards

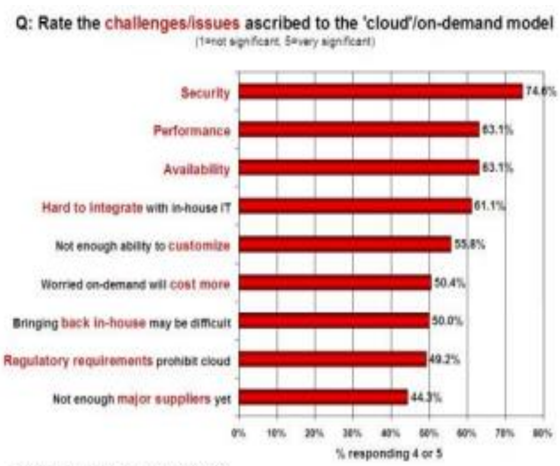

Figure 3. Factor which matters the most in cloud

Although SaaS providers must provide assurance that they are taking steps to mitigate breach risks, the responsibility for security cannot stop there. [12] Organizations that select SaaS solutions must also share security responsibility and implement internal procedures and processes. This includes education strategies to teach employees how to identify and respond to phishing campaigns, as well as setting company policies around what data should be placed in the cloud and what is better kept within the firewall. Just because an organization can store their data in the cloud doesn't mean that they should. [13] Organizations need to have a conversation with a trusted, knowledgeable partner to understand what (if any) data is best served on premise, in a hybrid setting, or totally "in the cloud" to understand the business and security consequences of doing so. Setting policies and best practices around what data may or may not need to be stored in the cloud can save numerous headaches, and potential data exposure and loss, later. head-on. When it comes down to it, most enterprises' security concerns are centered on the lack of control and visibility into how their data is stored and secured with SaaS vendors. There is a strong apprehension about insider breaches, along with vulnerabilities in the applications and systems' availability that could lead to loss of sensitive data and money. Such challenges can dissuade enterprises from adopting SaaS applications. The adoption of SaaS security practices (secure product engineering, secure deployment, GRC audits and regular SaaS security assessment) is vital to securing SaaS solutions. These can help identify any security issues upfront and ensure the safety of the data. SaaS vendors will benefit from the improved security of the solution and third-party validation of their security in the form of shortened sales cycles, and reduced operational risk. These measures will help them better answer any sales and marketing queries about security and address customer concerns. Customers will further be benefitted and assured about the security of their sensitive data and have higher confidence in the SaaS vendor. Thus, adoption of the above SaaS security strategies and regular SaaS security assessment can enable SaaS vendors to boost customer confidence in the security of their solution and enable its faster and wider adoption.

7. Conclusion

The Software as a Service (SaaS) model offers customers significant benefits, such as improved operational efficiency and reduced costs. However, to overcome customer concerns about application and data security, vendors must address these issues head-on. When it comes down to it, most enterprises' security concerns are centered on the lack of control and visibility into how their data is stored and secured with SaaS vendors. There is a strong apprehension about insider breaches, along with vulnerabilities in the applications and systems' availability that could lead to loss of sensitive data and money. Such challenges can dissuade enterprises from adopting SaaS applications. The adoption of SaaS security practices (secure product engineering, secure deployment, GRC audits and regular SaaS security assessment) is vital to securing SaaS solutions. These can help identify any security issues upfront and ensure the safety of the data. SaaS vendors will benefit from the improved security of the solution and third-party validation of their security in the form of shortened sales cycles, and reduced operational risk. These measures will help them better answer any sales and marketing queries about security and address customer concerns. Customers will further be benefitted and assured about the security of their sensitive data and have higher confidence in the SaaS vendor. Thus, adoption of the above SaaS security strategies and regular SaaS security assessment can enable SaaS vendors to boost customer confidence in the security of their solution and enable its faster and wider adoption

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