A Survey of Energy Efficiency in Cloud Datacenters

S.Prathiba[1], Dr.Sharmila Sankar[2]
[1]Dept of Computer Applications
[2]Dept of Computer Science & Engineering
[1, 2] B S Abdur Rahman Crescent Institute of Science & Technology

Abstract- *Energy efficiency in a datacenter is one of the major challenges in green computing. As the demands of the cloud service consumers increases, cloud service providers need to deliver the needs in an energy efficient way. Due to increase in demands, the power utilization of the resources in a datacenter increases. This paper gives a brief overview of different types of requests that arrive in a cloud datacenter, Challenges in power consumption, techniques adopted to reduce power consumption, and a methodology is proposed to make the server energy efficient.*

Keywords- power consumption, energy efficiency, data center

I. INTRODUCTION

There are several issues in cloud computing namely security issue, data issue, performance issue, bandwidth issue, energy efficiency issue, fault tolerance. This paper focuses on energy related issue. During the recent years, the energy consumption in a datacenter has increased rapidly due to the demands of the cloud users. IT equipment in a datacenter emit CO_2.The higher the load ,more power is consumed by the datacenter to keep it up and running which in turn emits higher carbon footprint. The power consumption in a datacenter involves several components namely the power consumed by the servers, cooling devices, storage devices. Among these components servers consume majority of the power as most of the datacenters run throughout the years.

According to Gartner report[30] refpaper1greengood1 the IT industry contributes 2% of the world's total CO_2 emissions. According to Mckinsey report on Revolutioning Data Center Energy efficiency, a typical datacenter consumes as much energy as 25000 households. A datacenter consumes electricity when IT and physical infrastructure loads are using power to process information or when elaborate cooling systems remove heat from the datacenter to keep temperature stable. The factors that have a major impact on datacenter power consumption are Datacenter Location, IT Load, and electricity.

A typical data centre contains the main units namely:

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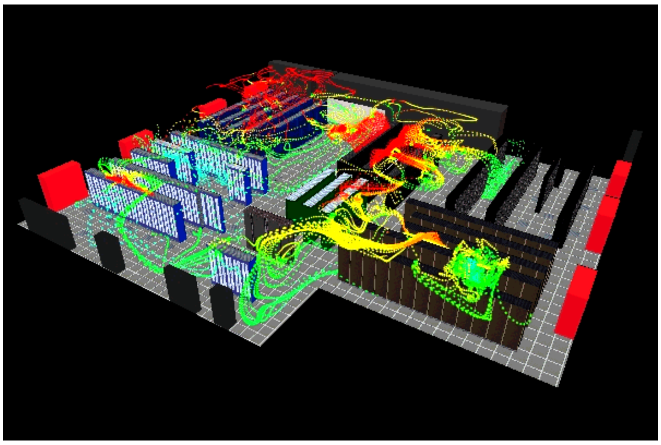

Figure. 1. Typical Datacenter

Heat Rejection, PumpRoom, Switch Gear, UPS, Emergency Generators, Power Distribution Unit, CRAC, ITroom. HeatRejecters are placed outside the main components which consist of dry coolers, chillers. These dry coolers receive chill water from pump rooms to maintain the temperature within a datacenter

Redundant Configurations are made to UPS device to support in times of power failure which are interconnected by means of switch gears. Diesel Generators are present within a datacenter to provide emergency power supply. IT room comprises of rack servers, blade servers which manipulates a data transfer in a typical grid suite.

Table 1. Power Consumption in a Datacenter

Component	Percentage of power consumption
Server	50
Air cooler	34
Conversion	7
Lighting	2

II. LITERATURE REVIEW

Cloud Computing is a on demand network which offers several benefits namely

1. Service Oriented
2. Autonomic
3. Dynamic and Distributed.

4. Pay as you use which offers shared economy
5. Elasticity
6. Virtualized environment

Cloud Computing emerged as a new technology since 1999 due to one of the following reasons: The Australian Open website received a seasonal spike in traffic during tournament period. Increase in traffic amounted to 100 times its typical volume. There was 22million requests in a couple of weeks Traditional datacenter was unable to handle this issue as running hundreds of servers is not a solution to this problem as these servers again consume energy .The solution to this problem resulted in the emergence of cloud computing. The cloud providers monitor and predict the demand and thus allocate the resources based on demand by means of virtualization. Users may request any type of service from cloud. A request can be any type of service namely Infrastructure as a Service(IaaS), Platform as a service(PaaS), Software as a Service(SaaS) In IaaS the resources are shared to the cloud consumers by the cloud providers. The virtual server space, bandwidth everything is offered to the client by the client service provider.

Millions of requests arrive in a cloud datacenter. A request or workload is something which is processed based on the sufficient allocation of resources. A workload or request arrives in a queue. A request received by the server can be heterogeneous i.e. each request will consume different set of resources depending on its type.

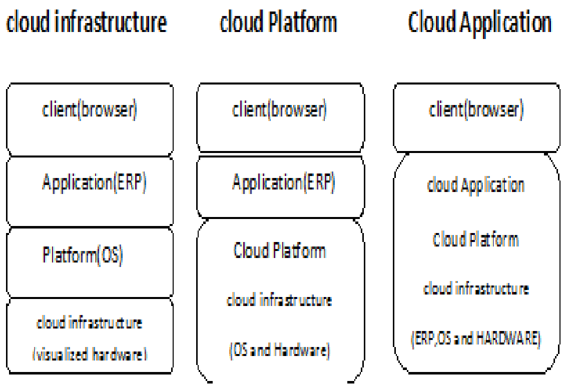

Figure. 2. The Cloud Architecture

A resource can be a server, CPU ,memory, bandwidth. Each request can go to different states when it is place in the queue. Any type of service namely Operating system, Database Management System, different tools for design and development can be shared in PaaS.Google,Facebook,Twitter etc. are examples of SaaS.

A request can be rejected, served, buffered or terminated. A request can be a video download, audio download, product reviews, picture, traffic update location update, an online purchase, exam result update etc.A request can be classified into different types in a cloud environment namely Batch requests, Analytic requests, High performance requests, Database requests, Transactional requests, Seasonal requests. The different types of requests is explained as follows:

A. Batch request

In a batch request, huge volumes of data are processed. A batch request can be a result of transactional statements that is generated every month.

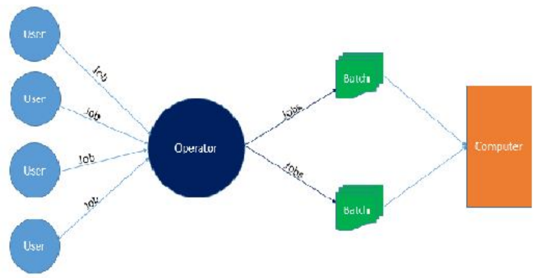

Figure. 3. Diagram for batch request

This kind of requests require large amount of storage and computational resources. Batch requests can be scheduled any time as they are not time sensitive. This type of request can be automated easily as data is available easily. In a real world, in the case of inter electronic funds transfer namely National Electronic Funds Transfer(NEFT) the request is processed in batches based on time schedule as per the government regulations.

B. Analytic requests

Organizations need to perform analysis on large amount of data to predict the growth of their business.

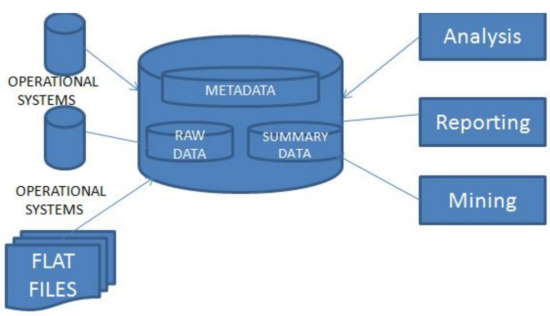

Figure. 4. Diagram for Analytic Request

The request for the data to be analyzed is performed on websites, private clouds within the organizations and the data warehouse. Processing this type of request requires complex computational capabilities.

C. High Performance Requests

This type of request needs to be processed with huge amount of resources as they are designed for scientific purposes to perform simulations.

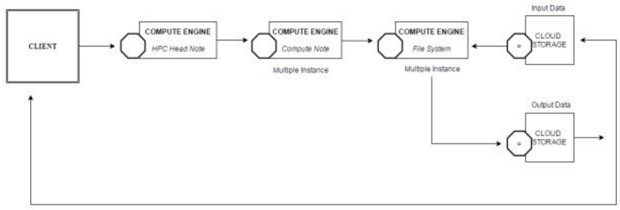

Figure. 5. Diagram for High Performance Requests

For example Monte Carlo simulations, Bioscience, Electronic design automation etc.

D. Database Requests

This type of request is the most common request that is used to support the service that is using the data.

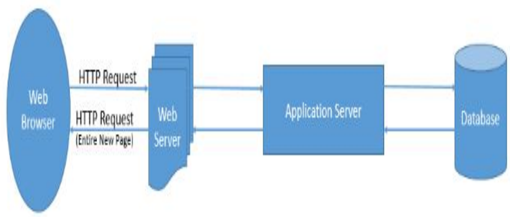

Figure. 6. Diagram for Database Requests

Depending on the type of request the performance of the system needs to be monitored periodically.

E. Transactional Requests

These type of requests correspond to billing and order processing.

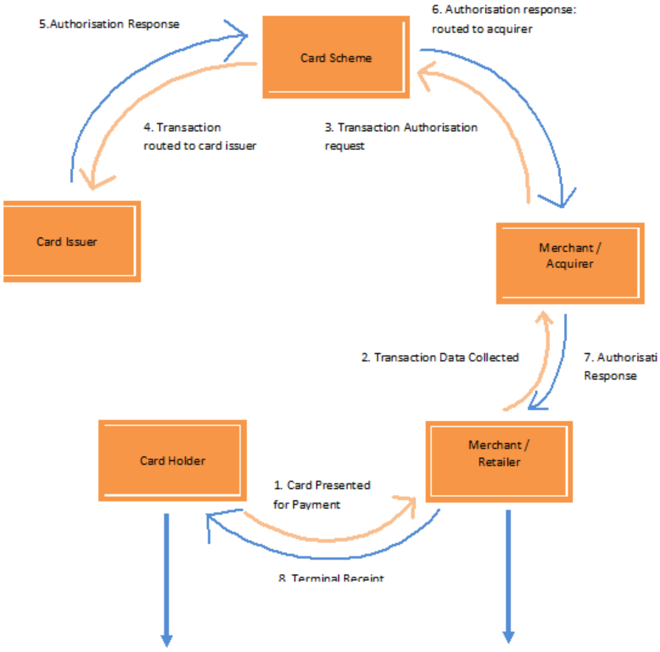

Figure. 7. Diagram for Transactional Requests

Due to the rapid growth of ecommerce, this kind of requests must be managed across various distributors in the computing environment.:

F. Seasonal requests

Seasonal Requests are those requests when the servers are overloaded with users requests.

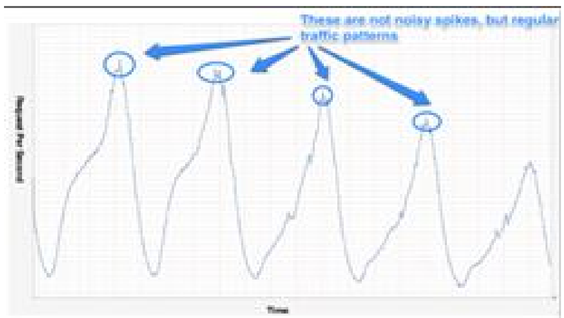

Figure. 8 .Diagram for seasonal Requests

Examples of seasonal requests include thanksgiving day in US, World Cup match, Olympics.

III. CHALLENGES IN POWER CONSUMPTION

The two major techniques adopted to reduce power consumption are Virtual Machine (VM)Migration, server consolidation.VM Migration plays a crucial role in load balancing of servers which in turn reduces power consumption. Once a host in a datacenter decides for live migration because the host is overloaded, the host should decide upon another host for live migration to take place. For that purpose, it should check which host is under loaded and the number of virtual machines that could be placed on that particular host. Server Virtualization provides flexibility and the resources are utilized effectively.

It degrades the performance of other servers when heavily utilized systems are virtualized and additional overhead is incurred. Consolidation is the process of merging multiple workloads under a single Operating system (OS) which reduces OS instances. Consolidation depends on the type of CPU's, servers, software that needs to be consolidated depending upon the vendors. Consolidation reduces software licensing cost and maintenance cost.

The other basic techniques for reducing power consumption includes Scheduling, Prediction, Load balancing ,Dynamic Frequency Voltage Scaling. Prediction is done based on past performance history. Load balancing between the servers is achieved by means of setting threshold limits. In the DVFS technique, the jobs placed in the servers are executed with low voltage frequency thus obtaining energy efficiency. A comparison of various techniques is shown in Table 2.

Table 2: Comparison of energy efficient techniques

Policy	**Technique used**	**Percentage of reduction in power consumption**	**Inference**
Greedy Minimum carbon emission	Greedy	20	
T-alloc algorithm	consolidation	20	
Efficient VM Migration, Optimized destination host selection	Double Exponential smoothing technique	34.59	
Stochastic right-sizing Model	Queuing theory	23.1	
Cloud energy management System	Sensors	30	
Stochastic right-sizing Model	Queuing theory	23.1	
Serial Migration and m Mixed Migration	Mathematical model		Migration time is reduced by increasing the transmission rate
Dynamic Resource Management Scheme	Dynamic Voltage/	50.3	
	frequency scaling and server consolidation		
Heuristic algorithm	Virtual Network embedding	40	
Allocation policy	Round Robin,	14	
	Striping, Packing, Load Balancing		
	(free CPU count), Load Balancing		
	(free CPU ratio), Watts per Core, Cost per Core.		
Green scheduling algorithm	Neural Network Prediction	46.3	

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