Energy Conservation using DVFS on cloud and fog for power cost efficient IoT devices environment

Project Report submitted in partial fulfillment of the requirement for the degree of

Master of technology

in

Computer Science & Engineering

Under the supervision of

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By

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Certificate

This is to certify that mid semester project report entitled **“Energy Conservation using DVFS on Cloud and fog for power cost efficient IoT environment ”,** submitted by **Piyush Chauhan** in partial fulfillment for the award of degree of Master of Technology in Computer Science & Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been made under my supervision.

This report has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

Date:

Supervisor’s Signature
Dr. Vivek Sehgal
Associate Professor

Acknowledgment

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Date: Signature:

Piyush Chauhan

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Abstract

Cloud computing and DVFS appeared as emerging technology makes organizations use software, hardware, Applications with absence of increased cost through internet. Fog computing brought computer services like storage, processing etc near to the end user device. Implementing the DVFS technique in cloud computing we can achieve significant reduction in power consumption in cloud computing servers and devices. Cloud computing and fo computing provide reliable, stable and efficient computing environment for user, because of this more user tend to adapt cloud computing environment at their workplaces. Cloud computing along with fog computing develop new opportunities for the businesses and IT sector. Advancement of digital devices and networking technologies lead to implementation of data centric task. These factors leads for the need of energy efficient task scheduling scheme for data center. Task scheduling algorithm is very important in cloud computing environment. Till now tasks scheduling issue is crucial issues in cloud computing architecture. Critical challenge with cloud computing service provider, effectively & efficiently use the computing resources like cloud servers, network, storage, processors, bandwidth etc so that all computing resources are more efficiently used. For decreasing execution cost of the workload task scheduling within the specified time and cost, Advance task scheduling algorithm is devised.

CHAPTER 1

INTRODUCTION

1.1 Cloud Computing

For the last more than twenty years World Wide Web developer have used images of cloud to demonstrate extremely greater number of communication details which takes place in network [33].

These communication details along with data flow across the World Wide Web network. With the advancement in the field of engineering of the computer devices computer services which includes the data processing, storage etc are easily provided to users.

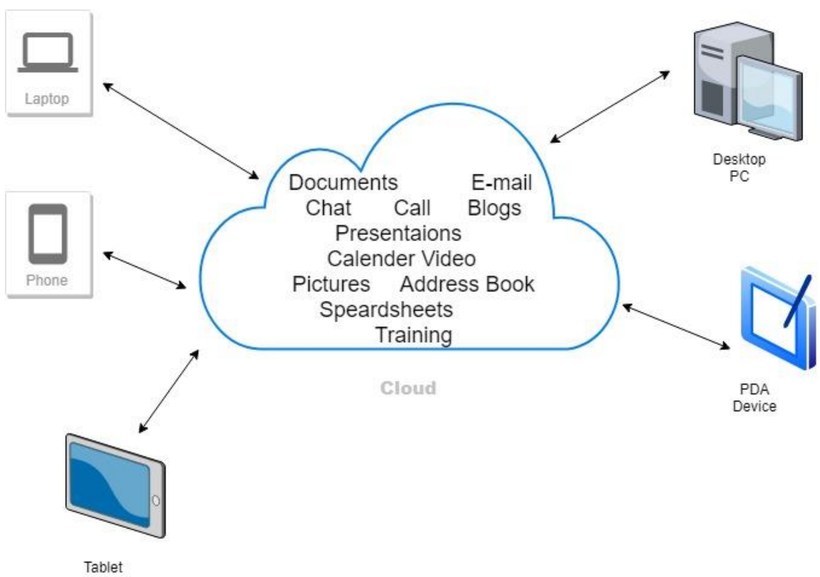

Figure 1.1 Cloud Computing

Cloud is believed to have been developed way back 1960 to enable people to process and share data across network ARPANET. Cloud Computing allow any user having debit/credit card to access the services like processing, storage , database and access to other resources as well as these as long as user need these.

Based on various factors such as location, usage of computing resources by cloud services can be categorized into different categories such as [34]:

1. **Public cloud –** Providing computer resources usage allowance to public. These services most often are maintained by the big enterprises and their resources are shared by their customers.

2. **Private cloud** – Intending computer resources for exclusive single specific organization. These services which includes data storage, processing of data and applications are shared by member of particular specific organization for various reasons such as security and to assure that these resources comply with various regulations.

3. **Hybrid cloud** – Combining features of both public cloud private. Like as enterprise may use resources of its own private cloud and also use public cloud with more capacity while maximum load on its cloud servers.

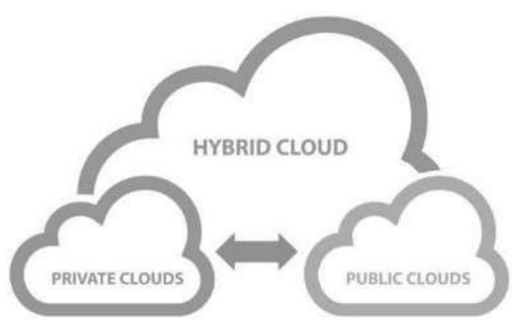

Figure 1.2 Hybrid Private and Public Cloud

4. **Multi cloud** –Using multiple cloud such as public, private and hybrid resources in a single heterogeneous architecture. There is similarity between multi cloud and hybrid cloud as users uses more than one service at the same time. Although while multi cloud not support the integration with public and private cloud as hybrid cloud does.

1.1.1 Cloud Service Models

Cloud resources and services are implemented according to user requirements. The services includes the following [21] [34]:

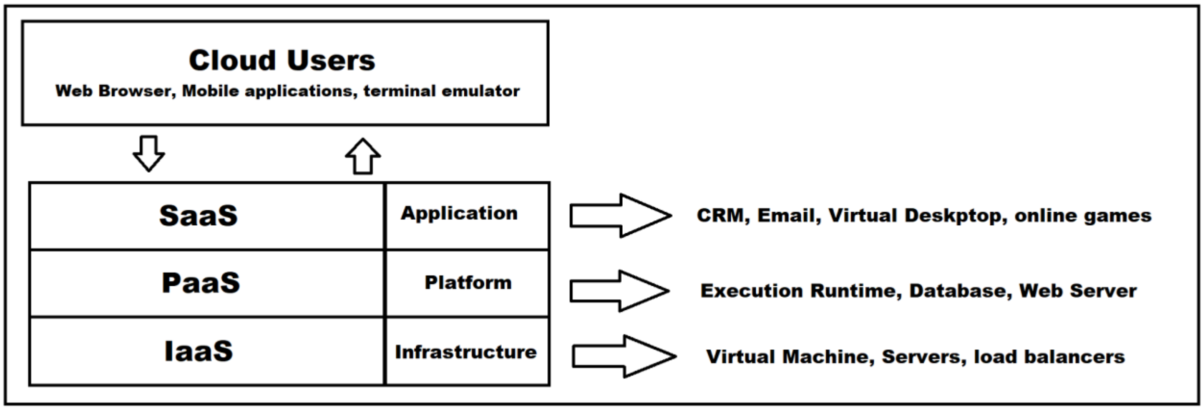

Figure 1.3 Cloud Platform

1. Software as a Service (SaaS)

SaaS modal enables an organization to provide their software on demand to user. In general in SaaS modal content is provided using web which users can access with the use of web browser.

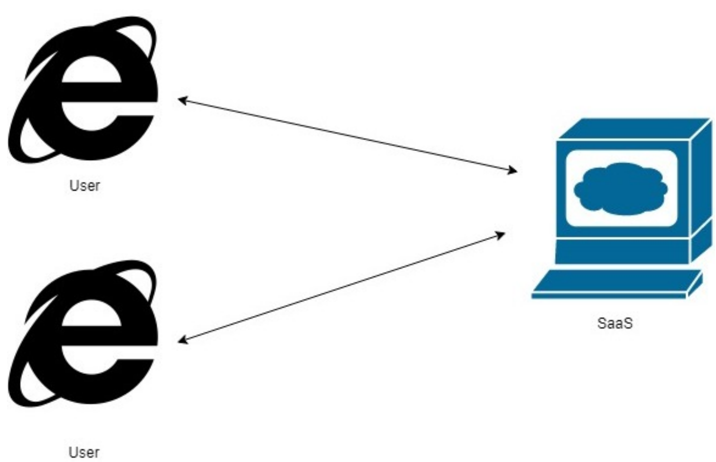

Figure 1.4 SaaS

2. Platform as a Service (PaaS)

PaaS modal provides the hardware resources like servers, operating system, database and developer tools to enable developers implement their client solution. Engineers need not to worry about worry about hardware upgrade. They can focus on their developed applications.

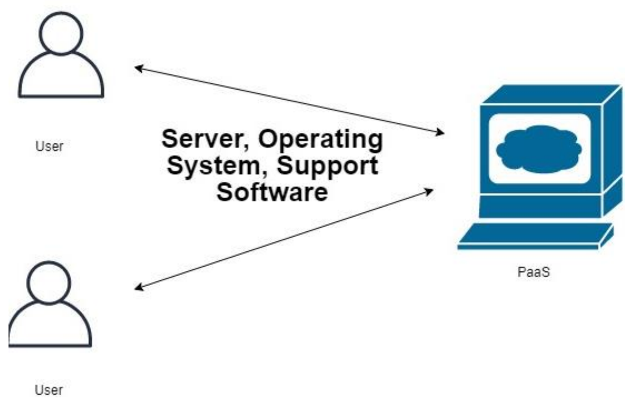

Figure 1.5 PaaS

3. Infrastructure as a Service (IaaS)

Modal enables organization provide their data centers virtually in the network. It enables the developers to install their operating system, database, softwares.

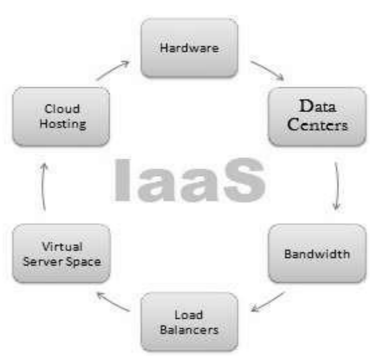

Figure 1.6 IaaS

1.1.2 Characteristics of Cloud Environments

As per NIST, most essential characteristic for cloud which are following:

1. On demand Self Service:

On demand self-service users can register themselves without user interaction with enterprise agent and can facilitate themselves with services provided by enterprises under the same network internet.

2. Broad network access:

Users access the World Wide Web network and services provided using internet. Users from different places are served by the same server providing storage and other resources.

3. Rapid services expansion:

User services can be scaled which means resources and services can be easily configured and released automatically in elastic way. User can experience unlimited ability for obtaining services in any quantity.

4. Measured service:

Environment where user need to pay only for the resources and given specific period of times with all the tracking of the storage capacity, computing, bandwidth. This makes the results transparent between the supplier and user fair basis for which invoice is made.

As we can see computing market is expanding and growing year after years and enterprises are becoming more aware of cost saving benefit of using cloud services. With latest hardware services, enterprises are able to use these resources without any additional cost.

This eventually also reduces the costly deployment and cost of maintenance of servers.

1.2 Dynamic Voltage Frequency Scaling (DVFS)

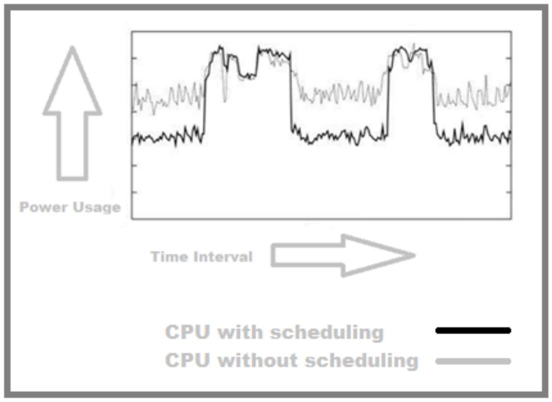

Figure 1.7 DVFS – Power Usage with respect to time

Dynamic Voltage and Frequency Scaling (DVFS) [24] is methodology to decrease the energy or power usage in the chip based integrated circuit used in devices like processor based devices or system by altering the processer working frequency scheduling algorithms. [25] It is the combination of the dynamic voltage scaling. This combination of both help to 7save the usage of the power consumption in the devices or system. Power usage consumption in the devices or system. Power usage consumption reduction is similar to the process same as in the way we turn off the devices or system. [26]Power reduction can be achieved by decreasing or increasing the frequency at which the processor run. Eventually this process also increases the total run time of the battery operated device or system. Advantages of the reduction of the power usage that the devices will generate less heating effect. This will eventually need to use less fan or cooling done as there is less amount of heat generated. [27] This is actually adjustment of power consumption and speed configuration on processors to make the resource allotment to every task along with increase power usage saving when these resources not required. This technique enables devices to complete needed task with lower amount of required power as compare to devices operating without DVFS technique.

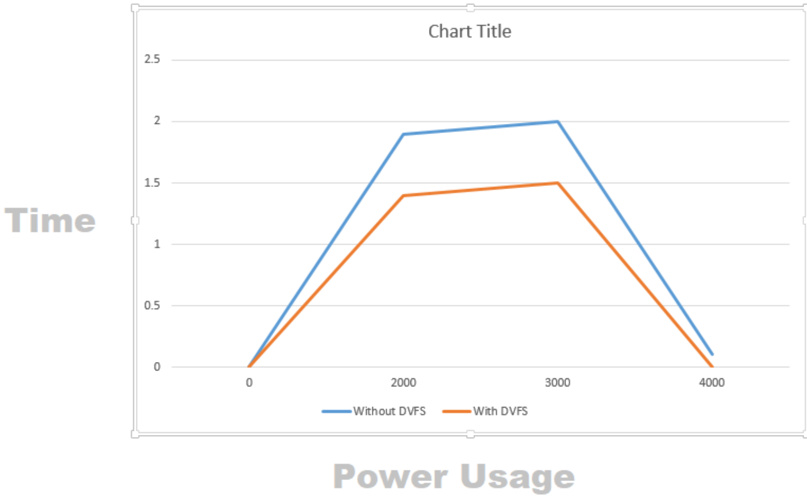

Figure 1.8 DVFS Energy Graph

This technology [28] is almost used in almost all computer oriented hardware to increase the power savings along with increase in device battery life to get more battery power while maintaining computing performance availability. Any device which are not being in use condition must change its state to a low power usage mode stopping request from other applications. Multimedia [29] applications needs higher power consumption as device power consumption increases and reaches higher power usage state it start creating more heat because of heating effect during higher processing at processor while using applications such as video and gaming which normally requires more computation. The noise along with higher power consumption during active cooling makes it difficult for small size devices to implement these cooling system architecture.

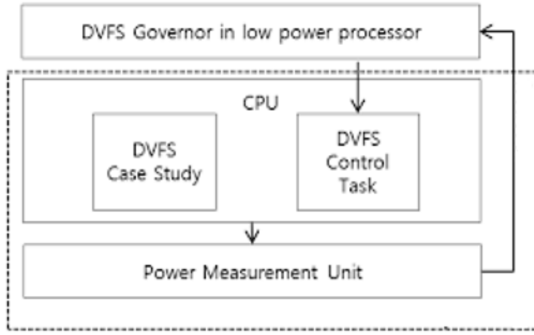

Figure 1.9 DVFS Module Deployment

Implementing the DVFS technique in cloud computing we can achieve significant reduction in power consumption in cloud computing servers and devices. Hence, we can conserve more power when task are being processed at lower voltage and frequency.

1.3 Fog Computing

Architecture of a system plays crucial role in its success. Fog computing makes the availability of the computing along with other services more faster speed to the devices in the same network fog computing architecture can be seen as a reliable way of providing services quickly along with the passing the broad network whose speed are mostly dependent on the carrier and network speed. It [29] is system or device level architecture that provides storage, control, networking functions to the users. This architecture avails to user low latency because of the nearby availability of the fog nodes. Fog nodes deployment is similar to cloud computing services like SaaS PaaS IaaS. Fog is mainly made up of the two inter related technologies. Cloudlets are the applications situated at the edge of network to provide the low latency in the device or system communication. Actually it is a fog node along with resources rich devices or system which is connected to the World Wide Web network. It mainly has total of the four attribute self-management, device power, low latency and some cloud services. In the hierarchical architecture cloudlets are located between the device cloudlets and cloud structure.

Mobile Edge Computing it is similar to mobile networking with in the wireless network. This architecture increases the cloud capabilities and information technology at the one end of the cellular network. There are many advantages of the fog computing as it provide compact devices geographical distribution along with mobility support. It provides low latency, location awareness and very much improvement in the quality of service.

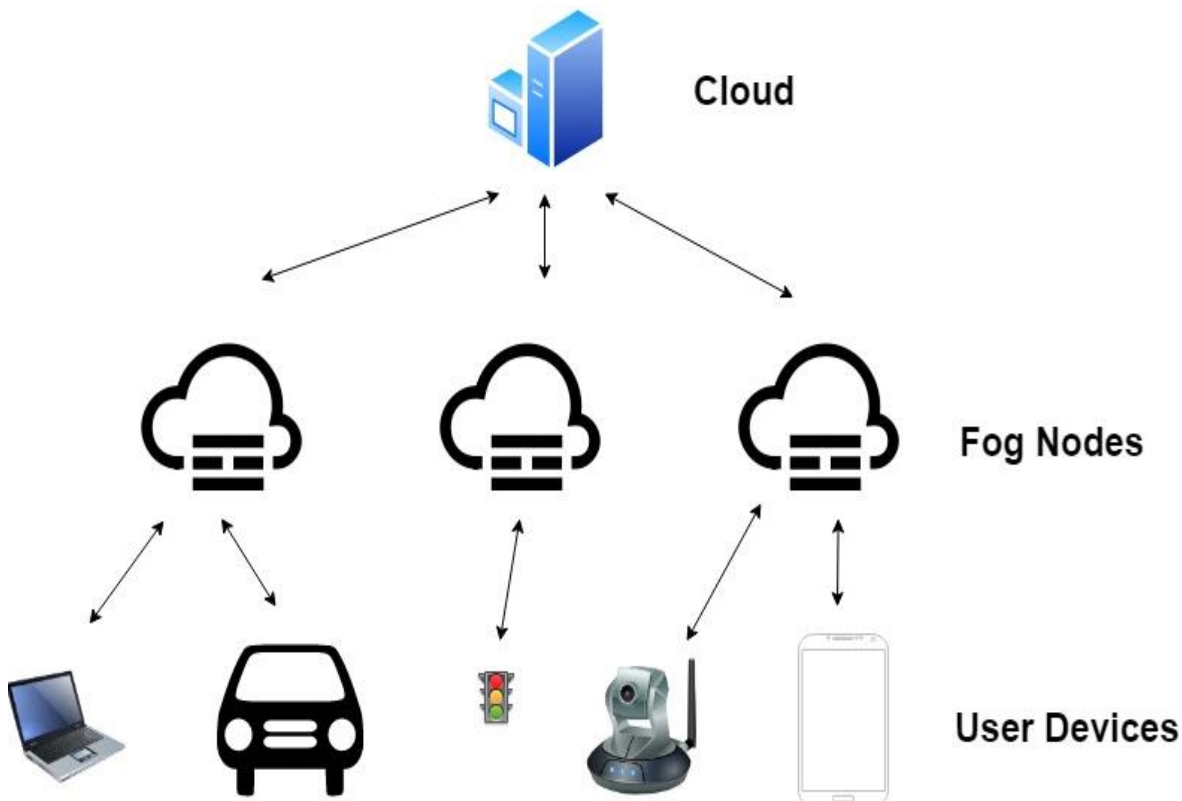

Figure 1.10 Fog Computing Architecture

More business agility and low operating cost. These important advantages of fog computing are very useful for the developer while designing and developing the applications.

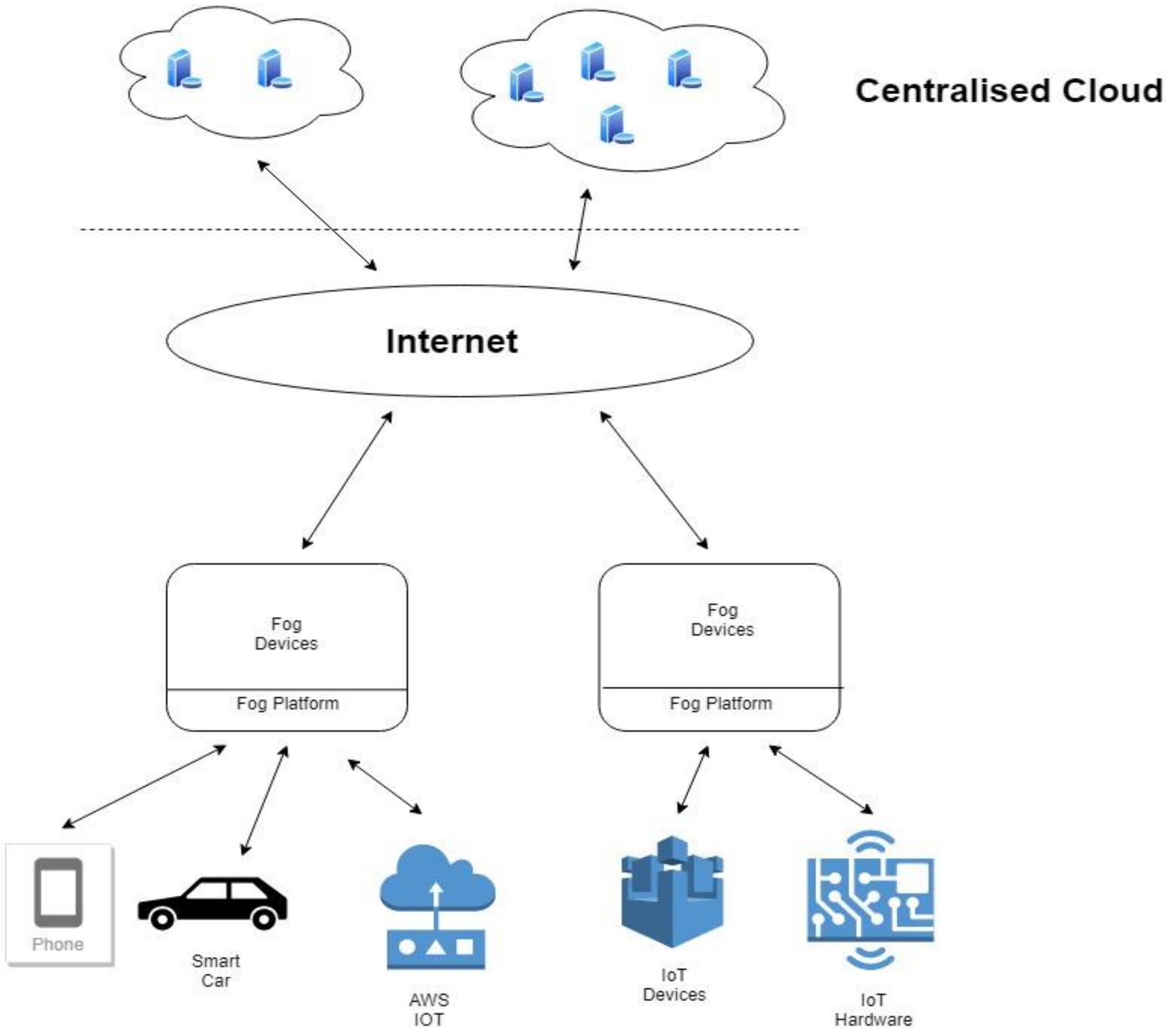

Figure 1.11 Fog computing

some critical fog issues with the fog architecture is very useful still it has some of the issues associated with it. Some security based issues with fog. Many of the security issues are still faced with fog computing as fog node are present at the edge of network and very close to the operating devices in the cloud which includes user authentication at different gateway level for example a device is connected and it had been allocated IP address and malicious user can easily change many configuration with this device and with false IP address can get access to admin configuration file. New approaches like minimum latency, network, bandwidth measurement, address security, collecting data securely across all the devices in the network and managing data processing effectively.

CHAPTER 2

LITERATURE SURVEY

Lin et al. [1] described methodology to enable mobile devices reduce power consumption using the algorithm in which mobile cloud computing in short MCC task scheduling is done. Algorithm creates a list of the task and make task schedule and after that it transfer the task to local unit to decrease the amount of power consumption. It check for the task that need that needed to be loaded to cloud and migrate other remaining tasks to the local unit and reduce the power consumed for processing all the task by calculating the execution time requirement and applying DVFS technique. This algorithm particularly optimizes the task on devices which are power backup from the battery source. This algorithm also uses other algorithm for the task migration in order to decrease scheduling delay while transferring the task to cloud.

Guan et al [2] using layer based architecture devised EvGPU. It has two layer control architecture which help in better performance by the graphical processing unit and is best for use in the cloud gaming. As we know in the architecture there are two layers in the first layer proportional Integral controller PIC is integrated which make sure SLA and count the all the frames per seconds for each game based between the specified level of the threshold. The second layer of two layer control architecture controls the graphical processing unit frequency and manipulate through DVFS after analyzing the frame per second. This process reduces the power consumption.

Jeyarani et al. [3] using pattern analyses power aware scheduler which check all the history of the arrivals tasks and after that it allocates the different resources. To reduces the power consumption and conserve power different policy are implemented like adaptive provisioning policy integrated with other policy like power aware allocation policy. Using these policy chip aware virtual machine is adjusted. Transition between sleep state and power saving is checked but still this organization of component methodology many times get failed to find the exact task requesting pattern.

Quan et al. [4] in his finding researched and proposed methodology to optimize the allocation of the resources and transfer the task workload to the processing unit. Depending on the allocation of the resources and distribution of the workload the operating frequency of the core in processor. This whole process is done by moving the application with much more load server to other server which has less load with latest operating system and software in order to conserve higher amount of power. All the server which are not getting the service request are put to sleep mode.

R.Jeyarani [5 proposed and mentioned a energy saving strategy which works in three phases. The task replication management use of the efficient algorithm to make changes in the servers cluster configuration and the machine state mode transition. It enables the energy management in more efficient way. Moreover in his performed experiment simulation proves that methodology is good for power conservation.

Rajkumar Buyya [6], in his research work devise PAVMP. Using this total power used in all the servers together can be reduced to significantly higher amount as comparatively to the usage. This methodology never effect the system's performance.

Liang Lua proposed [7] mentioned useful important tools which are necessary for the implementation of the simulator used for the energy conservation experiment DVFS technique is used for reducing the power conservation.

Amrit pal Singh proposed [8] mentioned a policy approach in his methodology. Policy introduces a new way to dynamically allocate the virtual machine. As per user requirement methodology take the virtual machine to the server. This help in improving system perform along with the reduction in the power usage.

Antomn Beloglzov [9] describe the information regarding the cloud and different services and resources served by the cloud environment. Author alos mentioned some virtual machine migration policies.

Hetal [10] introduces methodology in which host selction policy is introduced and two host are selected. Task mapping approach is used for the allocation of the virtual server for reducing the power usage further simulation experiment showed positive results regarding usage consumption,

Nikzad babis [11] devised algorithm to scale the frequency using DVFS. Algorithm showed in the simulation that there was reduction in the amount of the power usage by the processor. A formulae is devised in his work to optimize the energy consumption and in the final optimal frequency is choosen for achieving the reduction in the power usage.

[12] S. Nedachi [13] V. Valances showed methodology to achieve reduction in the energy consumption while sharing the large data files like video file chunks and other data from central data center server.

In [14] A. feldmam [15] J Baly a described the methodology to efficiently distribute among users. Central user similar to peer to peer data transfer from central server and showed this methodology conserve more energy as compare to the other modals in which data is transfer among devices. Author also showed that due to different models used among different user devices there is significant increase in overall usage across all the devices used during the whole process.

Author [16] [17] [18] proposed different architecture of cloud. These architecture cover the analysis of resources and implementing resource management efficiently and resolved many problems arises during transmission of data in the network.

M.M. Alabbadi [19] showed that cloud devices and fog devices uses cloud and fog architecture together for completing their task and many devices are depended on the each other.

R.Romana [20] described methodology to perform the analysis of all the information shared with the fog computing device inside the same network. It enable for the analytics done at global level using central data spread across the globe.

CHAPTER 3

PROBLEM DESCRIPTION

With the increase in the number of the devices along with the speed at which these devices are expanding to the peoples around the globe. There arises a lot of issues some of which are security, privacy, services, demand which are still growing. Along with these there comes increase in the demand of the power usage because of these demands. There are many projects were implemented like hydro projects to overcome these issues. Still hydro projects are not feasible everywhere because it needs structure like river flowing through mountains where dams can be constructed or built to generate the electric power. Unavailability of resources leads to development of other resources like tidal energy, wind energy etc. These resources are covered under the green computing. Still the demand for the green computing is getting completed to overcome these many coal based architecture to generate electricity to generate electricity are used. Further these have issue like production of the carbon dioxide which plays crucial role in the greenhouse effect. At the large level these power technique are associated with millions of devices together can conserve large sum of power.

Some crucial critical problems in cloud and fog computing resources:-

1. Wastage of Power usage

Absence of energy conservation technique in the devices results in the wastage of power and this further leads to growth of more power usage because of the power hungry devices.

2. Use of Resources for no purpose

It includes the selection of wrong devices or algorithm which require more power usage for completion of task which are not important.

3. Loss of Energy Loss

Due to unwanted errors which cannot be removed using today's technology there is loss of power usage in the devices.

4. Higher Power Consumption

Most of the computing resources uses the higher power consumption for the completion of the assigned workload. As the amount of power consumption increases a lot of energy is also wasted in the work of high around the computing devices.

5. Less Task Processing Rates

The task processing rate of the devices used for the cloud computing and devices used in the fog computing for the transfer of data is very less. 6. Loss of the critical data

A lot of data is wasted because of the bugs or error caused during the processing or transferring of data in the devices.

7. More Costing (in term of time and energy)

As the demand for the energy increases and less processing and data transferring rate leads to increase the cost in term of time and energy used for completion of the task.

CHAPTER 4

PROPOSED SOLUTION

In this project we will review small servers (Nano data centers) presented in user end devices for hosting and distributing content and applications in a peer-to-peer (P2P) fashion. These small server saves the data locally and transfer the data to the main server along with all the important information. Our devised methodology check for service request from the different devices on the network and processes the information using the algorithm and apply the appropriate configuration and setting to the frequency of the processor to use the power usage more efficiently with much more fast data processing rate. After completion of the process main server also provide result and percentage of the improvement in the processing rate along with the time associated with it. The fog comprises of fog nodes. There are different points of view on energy consumption during the data storage and data distribution among the user end devices/nodes. In this project, we aim to collaborate the fog computing and cloud computing resources for achieving lower energy consumption across the computing resources. We will look for the different points and analyze small servers and the centralized server and making them using lower power consumption. We will take an end to end network architecture which contains all the network resources used for the fog computing. Finding the way network nodes transmit the data, access the data from the central network data center and the small data center. After that we will look for the different energy consumption models for data distribution in our end network. Using the best techniques, we will lower the power consumption among the different fog computing resources to achieve the maximum efficiency with lower power consumption.

CHAPTER 5

METHODOLOGY

Implementation of DVFS contains installing the DVFS module.

Various steps after installing the module for the implementing the DVFS.

1. Initializing the Virtual Machine

2. Creating the data center

3. Create the host as the virtual machine is initialized and Nano Data Center are connected to host.

Applying the technique to the virtual machine server and the host. Our devised methodology check for the different factors like time, data space, frequency used for the processor.

Allocate cloudlets to the virtual machines. Set load after allocating cloudlets to virtual machines. Calculation of power consumption and time used at the regular time of interval. These interval are defined before starting the simulation. The underutilized host are detected. Switch off the underutilized host to lower power saving modes.

The energy saving algorithm that we are take use in our project here is DVFS. This technique keep checking after regular interval of time whether any host has utilization less than the average workload set in the previous step. If any such host is found that host is send on the power saving mode of DVFS. DVFS also has a provision according to which, a host with 0% utilization changes its state to sleep mode or power off mode to save the energy.

Keeping eye on the energy consumption by fog computing resources and the data centers associated with the fog devices.

Network topology for both Centralized Data Centers and Small Data Centers.

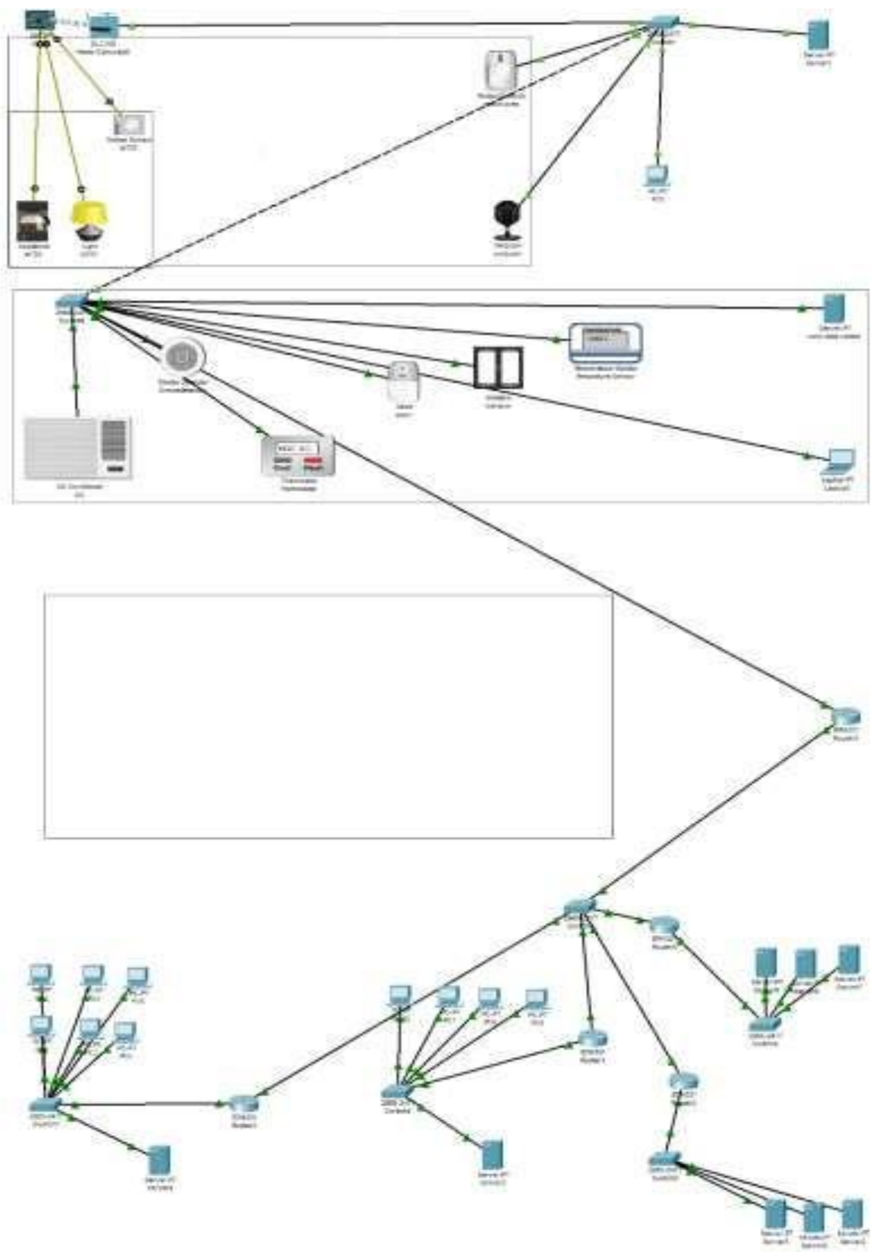

Figure 5.1 Topology of devices across the network

Network model for centralized data centers.

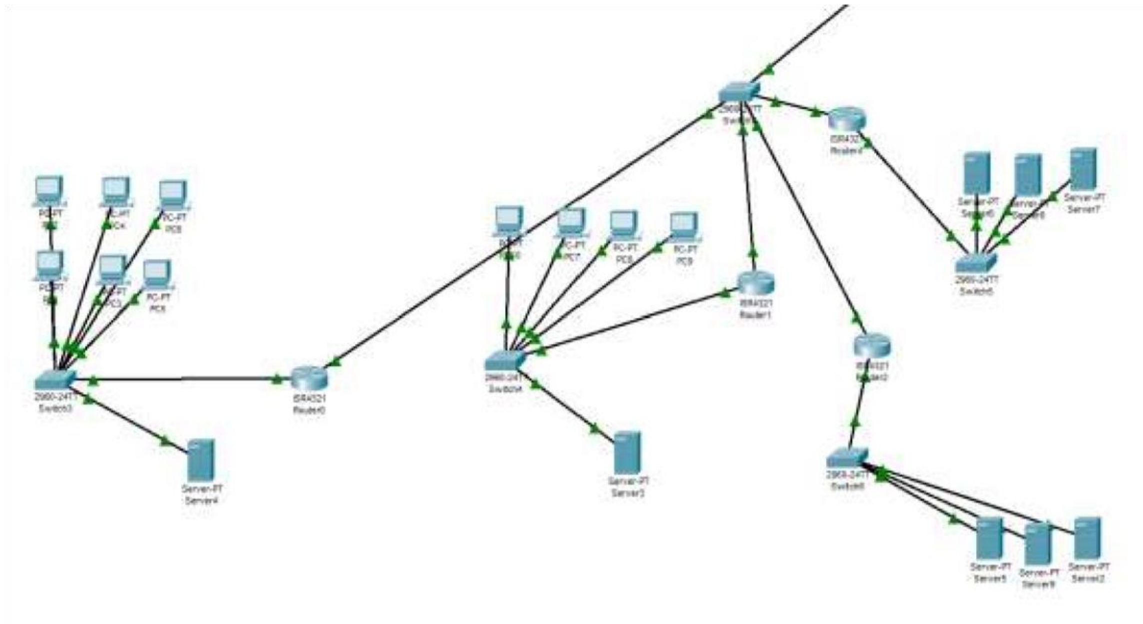

Figure 5.2 Topology of Cloud Servers

Energy consumption models for network equipment.

Energy consumed in Centralized Data Centers and small Data Centers.

Measurement of the following data:-

1. Traffic measurements.

2. Power measurements.

3. Energy consumption comparison.

CHAPTER 6

IMPLEMENTATION AND EXPERIMENT

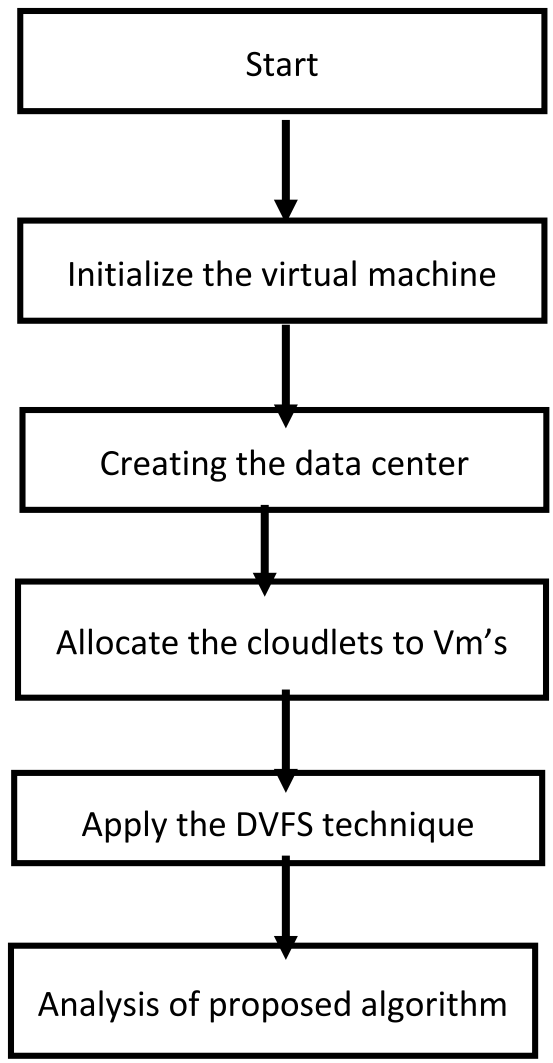

Fig. [c] DVFS Implementation Flow Diagram

After the initialization of the simulation setup which include turning on all the virtual servers and the electronic devices on the network the devices start. Devices starts sending data to the devices start sending data to the Nano data center. Nano data center using the DVFS process the data and store the information at the local unit. After a specified interval of time the data is transferred to the main server where all the data is collected and information is processed. Nano data center and the main server process the data with the DVFS configuration and setting and completes the task with much more improvement in the processing speed along with the reduction in the power usage.

Topology of the network and network devices are generated using the software cisco packet tracer. All the electronics devices can be made to change their working state to work idle or turn off or sleep mode. Topology shows the arrangement of these devices using the fog architecture along with the services from the cloud server environment. Using the cloudsim framework the DVFS algorithm is implemented.

Algorithm simulation is implemented using the JAVA Eclipse software. After the initialization of the simulation devices send request to turn on all the virtual device and start sending random data to the main server.

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Problems  @ Javadoc  Declaration  Search  Console  Progress
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Starting simulation round 1.
Initialising...
Starting CloudSim version 3.0
Datacenter is starting...
Entities started.
2.4000000059604645: Workflow execution started.
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Figure 6.1 Initialization of Cloudlets

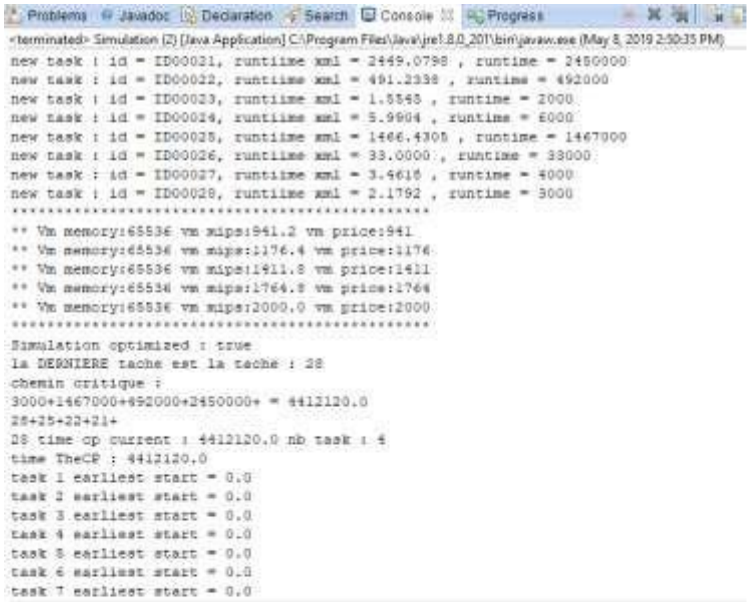


Figure 6.2 Initialization of task in cloudlets

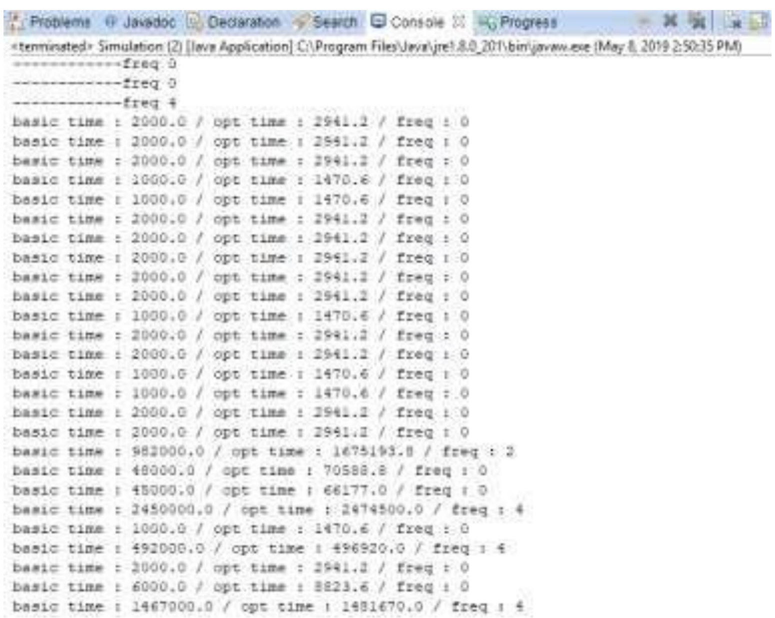
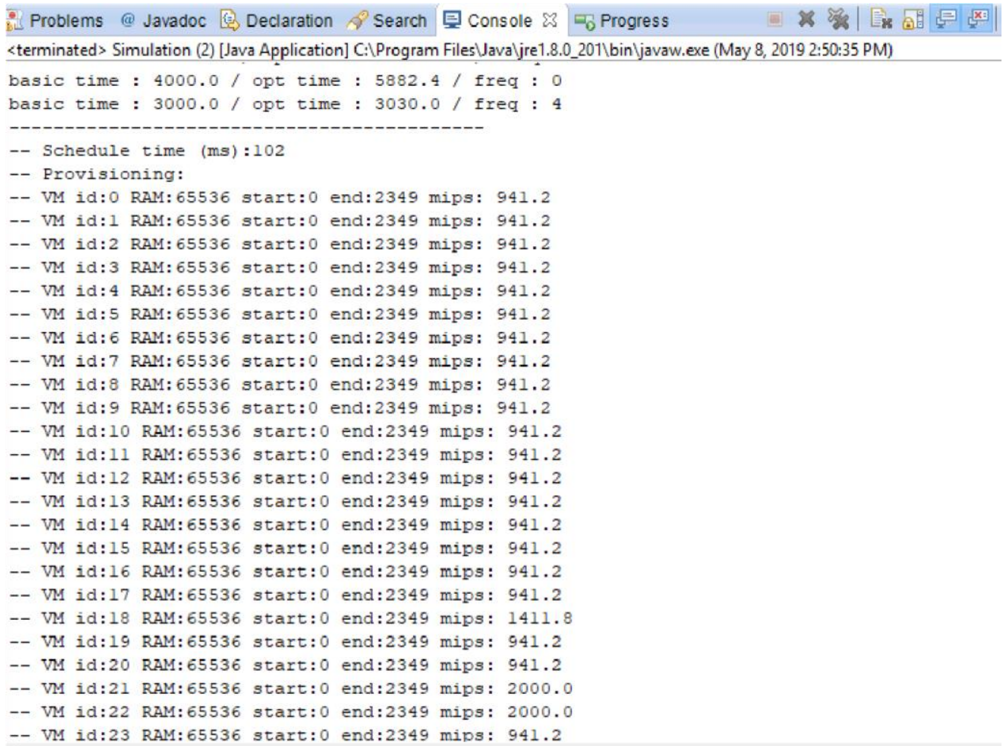


Figure 6.3 Task time measurement



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basic time : 3000.0 / opt time : 3030.0 / freq : 4
-------------------------------------------
-- Schedule time (ms):102
-- Provisioning:
-- VM id:0 RAM:65536 start:0 end:2349 mips: 941.2
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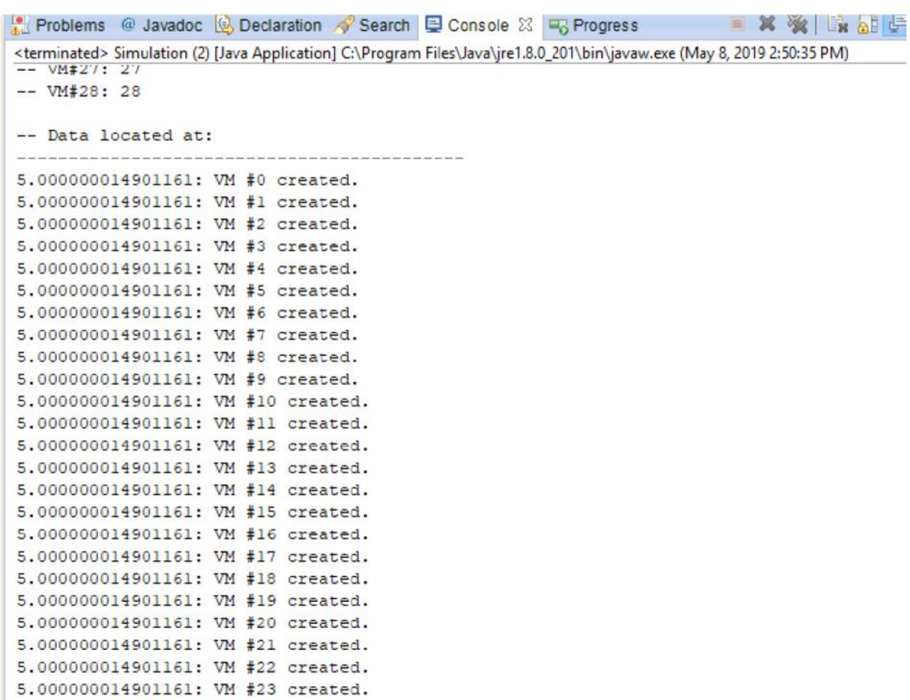
-- VM id:12 RAM:65536 start:0 end:2349 mips: 941.2
-- VM id:13 RAM:65536 start:0 end:2349 mips: 941.2
-- VM id:14 RAM:65536 start:0 end:2349 mips: 941.2
-- VM id:15 RAM:65536 start:0 end:2349 mips: 941.2
-- VM id:16 RAM:65536 start:0 end:2349 mips: 941.2
-- VM id:17 RAM:65536 start:0 end:2349 mips: 941.2
-- VM id:18 RAM:65536 start:0 end:2349 mips: 1411.8
-- VM id:19 RAM:65536 start:0 end:2349 mips: 941.2
-- VM id:20 RAM:65536 start:0 end:2349 mips: 941.2
-- VM id:21 RAM:65536 start:0 end:2349 mips: 2000.0
-- VM id:22 RAM:65536 start:0 end:2349 mips: 2000.0
-- VM id:23 RAM:65536 start:0 end:2349 mips: 941.2
```

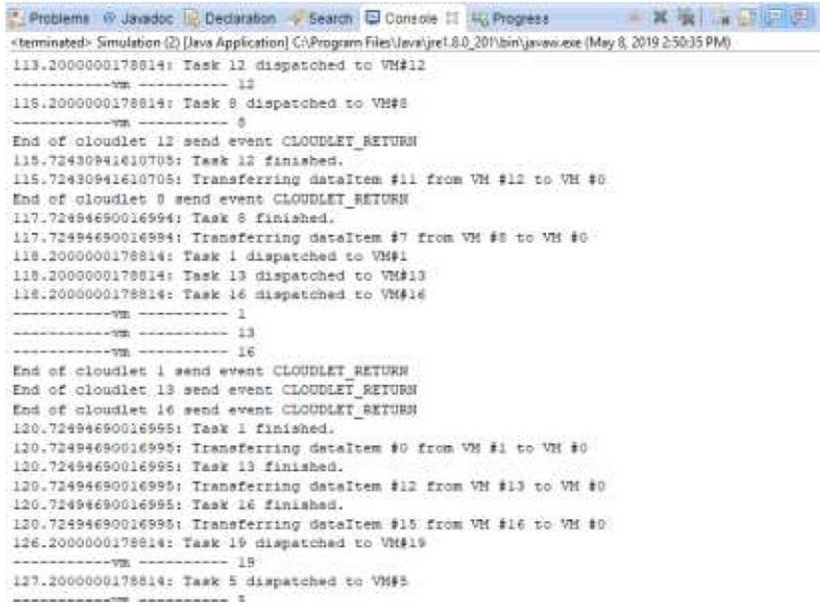
Figure 6.4 Initialize Virtual Machines



```
<terminated> Simulation (2) [Java Application] C:\Program Files\Java\jre1.8.0_201\bin\javaw.exe (May 8, 2019 2:50:35 PM)
-- VM#27: 27
-- VM#28: 28

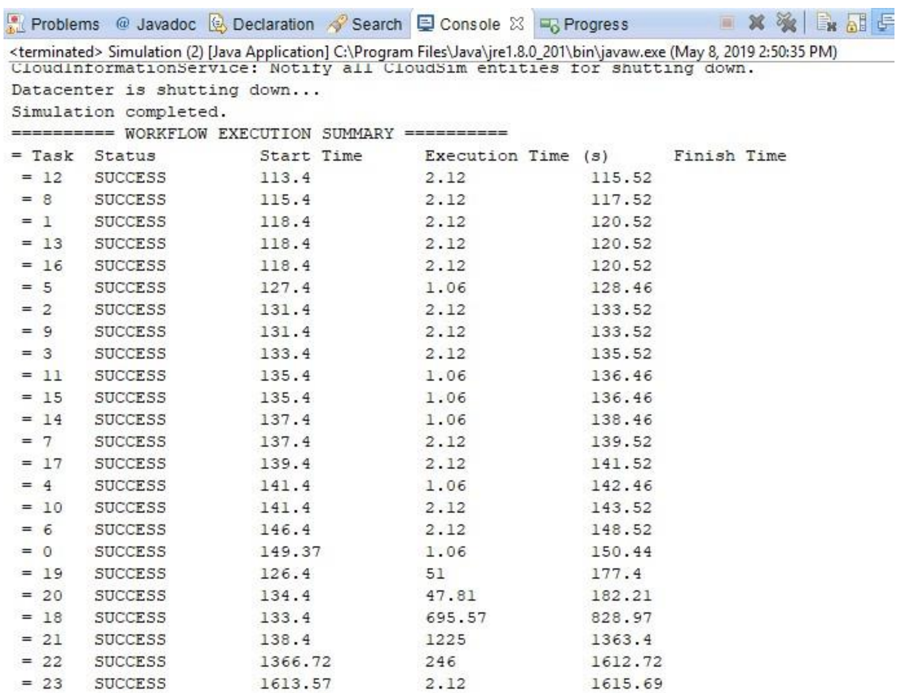
-- Data located at:
-------------------------------------------
5.000000014901161: VM #0 created.
5.000000014901161: VM #1 created.
5.000000014901161: VM #2 created.
5.000000014901161: VM #3 created.
5.000000014901161: VM #4 created.
5.000000014901161: VM #5 created.
5.000000014901161: VM #6 created.
5.000000014901161: VM #7 created.
5.000000014901161: VM #8 created.
5.000000014901161: VM #9 created.
5.000000014901161: VM #10 created.
5.000000014901161: VM #11 created.
5.000000014901161: VM #12 created.
5.000000014901161: VM #13 created.
5.000000014901161: VM #14 created.
5.000000014901161: VM #15 created.
5.000000014901161: VM #16 created.
5.000000014901161: VM #17 created.
5.000000014901161: VM #18 created.
5.000000014901161: VM #19 created.
5.000000014901161: VM #20 created.
5.000000014901161: VM #21 created.
5.000000014901161: VM #22 created.
5.000000014901161: VM #23 created.
```

Figure 6.5 Initialize Virtual Servers



```
Problems  @ Javadoc  Declaration  Search  Console  Progress
<terminated> Simulation (2) [Java Application] C:\Program Files\Java\jre1.8.0_201\bin\javaw.exe (May 8, 2019 2:50:35 PM)
113.2000000178814: Task 12 dispatched to VM#12
-----------vm ---------- 12
115.2000000178814: Task 8 dispatched to VM#8
-----------vm ---------- 8
End of cloudlet 12 send event CLOUDLET_RETURN
115.72430941610705: Task 12 finished.
115.72430941610705: Transferring dataItem #11 from VM #12 to VM #0
End of cloudlet 8 send event CLOUDLET_RETURN
117.72494690016994: Task 8 finished.
117.72494690016994: Transferring dataItem #7 from VM #8 to VM #0
118.2000000178814: Task 1 dispatched to VM#1
118.2000000178814: Task 13 dispatched to VM#13
118.2000000178814: Task 16 dispatched to VM#16
-----------vm ---------- 1
-----------vm ---------- 13
-----------vm ---------- 16
End of cloudlet 1 send event CLOUDLET_RETURN
End of cloudlet 13 send event CLOUDLET_RETURN
End of cloudlet 16 send event CLOUDLET_RETURN
120.72494690016995: Task 1 finished.
120.72494690016995: Transferring dataItem #0 from VM #1 to VM #0
120.72494690016995: Task 13 finished.
120.72494690016995: Transferring dataItem #12 from VM #13 to VM #0
120.72494690016995: Task 16 finished.
120.72494690016995: Transferring dataItem #15 from VM #16 to VM #0
126.2000000178814: Task 19 dispatched to VM#19
-----------vm ---------- 19
127.2000000178814: Task 5 dispatched to VM#5
-----------vm ---------- 5
```

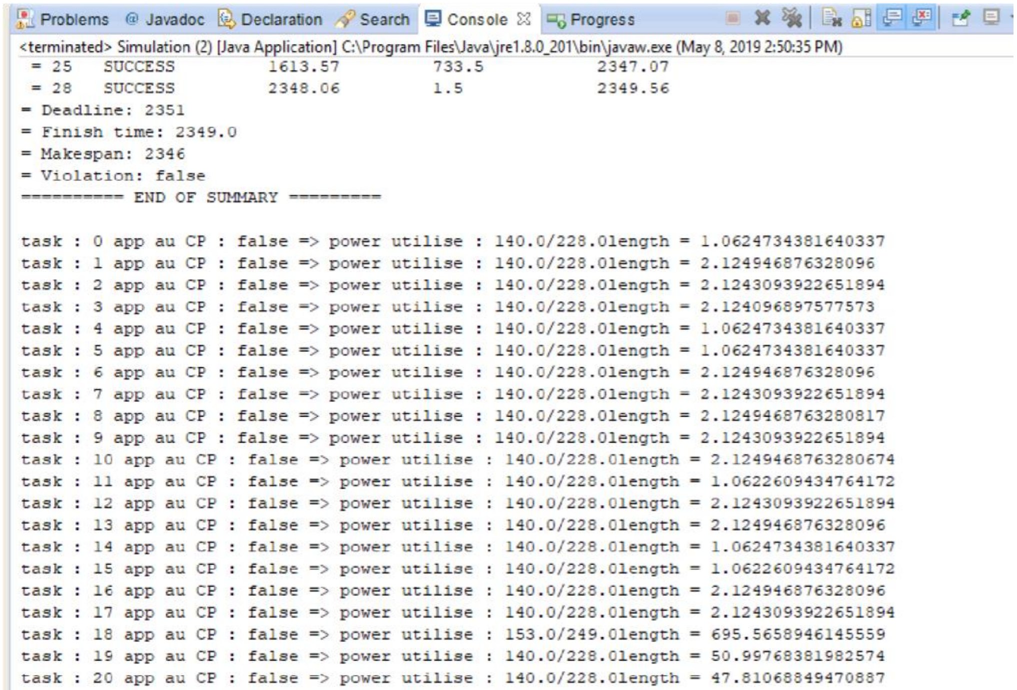
Figure 6.6 Turning off cloudlets after completion of task



```
Problems  @ Javadoc  Declaration  Search  Console  Progress
<terminated> Simulation (2) [Java Application] C:\Program Files\Java\jre1.8.0_201\bin\javaw.exe (May 8, 2019 2:50:35 PM)
CloudInformationService: Notify all CloudSim entities for shutting down.
Datacenter is shutting down...
Simulation completed.
========== WORKFLOW EXECUTION SUMMARY ==========
```

= Task	Status	Start Time	Execution Time (s)	Finish Time
= 12	SUCCESS	113.4	2.12	115.52
= 8	SUCCESS	115.4	2.12	117.52
= 1	SUCCESS	118.4	2.12	120.52
= 13	SUCCESS	118.4	2.12	120.52
= 16	SUCCESS	118.4	2.12	120.52
= 5	SUCCESS	127.4	1.06	128.46
= 2	SUCCESS	131.4	2.12	133.52
= 9	SUCCESS	131.4	2.12	133.52
= 3	SUCCESS	133.4	2.12	135.52
= 11	SUCCESS	135.4	1.06	136.46
= 15	SUCCESS	135.4	1.06	136.46
= 14	SUCCESS	137.4	1.06	138.46
= 7	SUCCESS	137.4	2.12	139.52
= 17	SUCCESS	139.4	2.12	141.52
= 4	SUCCESS	141.4	1.06	142.46
= 10	SUCCESS	141.4	2.12	143.52
= 6	SUCCESS	146.4	2.12	148.52
= 0	SUCCESS	149.37	1.06	150.44
= 19	SUCCESS	126.4	51	177.4
= 20	SUCCESS	134.4	47.81	182.21
= 18	SUCCESS	133.4	695.57	828.97
= 21	SUCCESS	138.4	1225	1363.4
= 22	SUCCESS	1366.72	246	1612.72
= 23	SUCCESS	1613.57	2.12	1615.69

Figure 6.7 Simulation - Datacenter runtime data



```
Problems @ Javadoc Declaration Search Console Progress
<terminated> Simulation (2) [Java Application] C:\Program Files\Java\jre1.8.0_201\bin\javaw.exe (May 8, 2019 2:50:35 PM)
 = 25   SUCCESS        1613.57        733.5          2347.07
 = 28   SUCCESS        2348.06        1.5            2349.56
= Deadline: 2351
= Finish time: 2349.0
= Makespan: 2346
= Violation: false
========== END OF SUMMARY =========

task : 0 app au CP : false => power utilise : 140.0/228.0length = 1.0624734381640337
task : 1 app au CP : false => power utilise : 140.0/228.0length = 2.124946876328096
task : 2 app au CP : false => power utilise : 140.0/228.0length = 2.1243093922651894
task : 3 app au CP : false => power utilise : 140.0/228.0length = 2.124096897577573
task : 4 app au CP : false => power utilise : 140.0/228.0length = 1.0624734381640337
task : 5 app au CP : false => power utilise : 140.0/228.0length = 1.0624734381640337
task : 6 app au CP : false => power utilise : 140.0/228.0length = 2.124946876328096
task : 7 app au CP : false => power utilise : 140.0/228.0length = 2.1243093922651894
task : 8 app au CP : false => power utilise : 140.0/228.0length = 2.1249468763280817
task : 9 app au CP : false => power utilise : 140.0/228.0length = 2.1243093922651894
task : 10 app au CP : false => power utilise : 140.0/228.0length = 2.1249468763280674
task : 11 app au CP : false => power utilise : 140.0/228.0length = 1.0622609434764172
task : 12 app au CP : false => power utilise : 140.0/228.0length = 2.1243093922651894
task : 13 app au CP : false => power utilise : 140.0/228.0length = 2.124946876328096
task : 14 app au CP : false => power utilise : 140.0/228.0length = 1.0624734381640337
task : 15 app au CP : false => power utilise : 140.0/228.0length = 1.0622609434764172
task : 16 app au CP : false => power utilise : 140.0/228.0length = 2.124946876328096
task : 17 app au CP : false => power utilise : 140.0/228.0length = 2.1243093922651894
task : 18 app au CP : false => power utilise : 153.0/249.0length = 695.5658946145559
task : 19 app au CP : false => power utilise : 140.0/228.0length = 50.99768381982574
task : 20 app au CP : false => power utilise : 140.0/228.0length = 47.81068849470887
```

Figure 6.8 Summary of Simulation

The energy saving algorithm that we are take use in our project here is DVFS. This technique keep checking after regular interval of time whether any host has utilization less than the average workload set in the previous step. If any such host is found that host is send on the power saving mode of DVFS. DVFS also has a provision according to which, a host with 0% utilization changes its state to sleep mode or power off mode to save the energy.

Simulation Results:

```
Result.txt - Notepad
File  Edit  Format  View  Help
DAG_FILE - dag/Sipht_30.xml   OPTIMIZE - true   DVFS Mode - optimal   Energy - 2815.3556393114536   End Time - 2349.0
DAG_FILE - dag/Sipht_30.xml   OPTIMIZE - false   DVFS Mode - optimal   Energy - 3241.1699125020855   End Time - 2349.0
```

Figure 6.9 Simulation Result

```
DAG_FILE - dag/Sipht_30.xml

OPTIMIZE - false
DVFS Mode - optimal
Energy - 3241.1699125020855
End Time - 2349.0
DAG_FILE - dag/Sipht_30.xml

OPTIMIZE - true
DVFS Mode - optimal
Energy - 2815.3556393114536
End Time - 2349.0
DAG_FILE - dag/Sipht_30.xml

OPTIMIZE - false
DVFS Mode - optimal
Energy - 3241.1699125020855
End Time - 2349.0
DAG_FILE - dag/Sipht_30.xml

OPTIMIZE - true
DVFS Mode - optimal
Energy - 2815.3556393114536
End Time - 2349.0
```

Figure 6.10 Simulation Result Comparison

Result shows when the **DVFS Optimization** is set to **True** and DVFS Mode is optimal the energy used by the virtual machine is lower.

CHAPTER 7

CONCLUSION

Using the advance algorithms we can measure the different like time, clock frequency of the processor during the service request and processing of the data in the processor. In this project we used different electronic devices and the sensor. These devices send the information is processed and then the useful information it send to the main server with regular interval of time. Moreover the simulation result showed for example as there are a lot of devices installed in Danielle Swanny's hospital including the sensor's device. Using our methodology the simulation showed there was reduction in power usage by the devices. If these technique all used at large global level we can achieve a lot of energy conservation leading to green computing.

Hence, our simulation result showed there is reduction in the power usage among the devices we used.

CHAPTER 8

FUTURE WORK

Cloud Computing is growing and its use is increasing from big organizations to the home user.

This results in the increase in the demand of the cloud computing resources. With the introduction of the Internet of Things (IoT) use of the cloud computing emerged as backbone for these services.

Advanced Scheduling Algorithm reduces the power consumption and increased the efficiency to a greater extent. This provides a vast area where further research can be done to make efficient user of the power consumption and processing power of the cloud servers.

References :

1. Lin X., Wang Y., Xie Q., Pedram M. Task scheduling with dynamic voltage and frequency scaling for energy minimization in the mobile cloud computing environment. IEEE Transactions on Services Computing. 2014;8(2):175–186. doi: 10.1109/tsc.2014.2381227.

2. Guan H., Yao J., Qi Z., Wang R. Energy-efficient SLA guarantees for virtualized GPU in cloud gaming. IEEE Transactions on Parallel and Distributed Systems. 2014;26(9):2434–2443. doi: 10.1109/TPDS.2014.2350499.

3. Jeyarani R., Nagaveni N., Sadasivam S. K., Rajarathinam V. R. Power aware meta scheduler for adaptive VM provisioning in IaaS cloud. International Journal of Cloud Applications and Computing. 2011;1(3):36–51. doi: 10.4018/ijcac.2011070104.

4. Quan D. M., Mezza F., Sannenli D., Giafreda R. T-Alloc: a practical energy efficient resource allocation algorithm for traditional data centers. Future Generation Computer Systems. 2012;28(5):791– 800. doi: 10.1016/j.future.2011.04.020.

5. R. Jeyarani a, N. Nagaveni , R. Vasanth Ram, Design and implementation of adaptive poweraware virtual machine provisioner (APA-VMP) using swarm intelligence, Future Generation Computer Systems 28 (2012) 811–821.

6. Rajkumar Buyya, Anton Beloglazov, and Jemal Abawajy, Energy- Efficient Management of Data Center Resources for Cloud Computing: A Vision, Architectural Elements, and Open Challenges, 2010, CSREA Press.

7. Liang Luo, Wenjun Wua, W.T. Tsai, Dichen Di, Fei Zhang, Simulation of power consumption of cloud data centers, Simulation Modelling Practice and Theory 39 (2013) 152–171.

8. Amritpal Singh, Supriya Kinger, Virtual Machine Migration Policies in Cloud, International Journal of Science and Research (IJSR), India Online ISSN: 23197064 Volume 2 Issue 5, May 2013.

9. Anton Beloglazov and Rajkumar Buyya, Optimal Online Deterministic Algorithms and Adaptive Heuristics for Energy and Performance Efficient Dynamic Consolidation of Virtual Machines in Cloud Data Centers, CONCURRENCY AND COMPUTATION: PRACTICE AND EXPERIENCE Concurrency Computat.: Pract. Exper. 2012; 24:1397–1420.
10. Hetal Joshiyara, Energy Efficient Provisioning of Virtual Machines in Cloud System using DVFS, INDIAN JOURNAL OF RESEARCH Volume : 3 |Issue : 4 | May 2013
11. Nikzad Babaii Rizvandi, Javid Taheri, Albert Y.Zomaya, Young Choon Lee, Linear combinations of DVFS-enabled processor frequencies to modify the energy-aware scheduling algorithms, in: Proc. of the 2010 10th IEEE/ACM International Conference.
12. V. Valancius, N. Laoutaris, L. Massouli´e, C. Diot, and P. Rodriguez, "Greening the internet with nano data centers," in Proceedings of the 5th international conference on Emerging networking experiments and technologies, ser. CoNEXT '09, 2009, pp. 37–48.
13. S. Nedevschi, S. Ratnasamy, and J. Padhye, "Hot data centers vs. cool peers," in Proceedings of the 2008 conference on Power aware computing and systems, ser. HotPower'08, 2008, pp. 8–8.
14. A. Feldmann, A. Gladisch, M. Kind, C. Lange, G. Smaragdakis, and F. Westphal, "Energy trade-offs among content delivery architectures," in Telecommunications Internet and Media Techno Economics (CTTE), 2010 9th Conference on, 2010, pp. 1–6.
15. J. Baliga, R. Ayre, K. Hinton, and R. Tucker, "Architectures for energyefficient iptv networks," in Optical Fiber Communication - incudes post deadline papers, 2009. OFC 2009. Conference on, March 2009, pp. 1–3. [16] M. Patel et al., "Mobile-edge computing," in ETSI White Paper, September 2014.
16. M. Aazam and E.-N. Huh, "Fog computing micro datacenter based dynamic resource estimation and pricing model for IoT," in IEEE 29th International

Conference on Advanced Information Networking and Applications, Gwangju, South Korea, March 2015, pp. 687–694.

17. L. F. Bittencourt, M. M. Lopes, I. Petri, and O. F. Rana, “Towards virtual machine migration in fog computing,” in Proc. of International Conference on P2P, Parallel, Grid, Cloud and Internet Computing (3PGCIC), Krakow, Poland, November 2015, pp. 1– 8.
18. R. Romana, J. Lopeza, and M. Mambob, “Mobile Edge Computing, Fog et al: A Survey and Analysis of Security threats and challenges,” Future Generation Computer Systems, Elsevier, 2016.
19. M. M. Alabbadi, “Cloud Computing for Education and Learning: Education and Learning as a Service (ELaaS),” 2011 14th International Conference on Interactive Collaborative Learning (ICL), pp. 589 – 594, DOI=21-23 Sept. 2011.
20. J. Montes, A. Sánchez, B. Memishi, M.S. Pérez, G. Antoniu, GMonE: A complete approach to cloud monitoring, Future Gener. Comput. Syst. 29 (8) (2013) 2026–2040.R. Trapero, J. Modic, M. Stopar
21. Cloud Computing – Research Issues, Challenges, Architecture, Platforms and Applications: Santosh Kumar and R. H. Goudar International Journal of Future Computer and Communication, Vol. 1, No. 4, December 2012
22. Dynamic Voltage and Frequency Scaling-aware dynamic consolidation of virtual machines for energy efficient cloud data centers Patricia Arroba1,2 José M. Moya1,2 José L. Ayala3 DOI: 10.1002/cpe.4067
23. Wu CM, Chang RS, Chan HY. A green energy-efficient scheduling algorithm using the dvfs technique for cloud datacenters. Future Gener Comput Syst. 2014;37(0):141–147.
24. Maio VD, Prodan R, Benedict S, Kecskemeti G. Modelling energy consumption of network transfers and virtual machine migration. Future Gener Comput Syst. 2016;56:388– 406.

25. An Energy aware Scheduling Algorithm in DVFS-enabled Networked Data Centers Mohammad Shojafar1, Claudia Canali1, Riccardo Lancellotti1 and Saeid Abolfazli2 Future Gener Comput Syst. 2015;769(0):249–307.

26. Reducing Energy Consumption with Dvfs for Real-Time Services in Cloud Computing 1Vrunda J. Patel, 2Prof. Hitesh A. Bheda IOSR Journal of Computer Engineering (IOSR-JCE) e-ISSN: 2278-0661, p- ISSN: 2278-8727Volume 16, Issue 3, Ver. II (May-Jun. 2014), PP 53-57

27. Fog and IoT: An Overview of Research Opportunities Mung Chiang ; Tao Zhang IEEE ISSN Information:Electronic ISSN: 2327-4662 CD-ROM ISSN: 2372-2541 INSPEC Accession Number: 16585171 DOI: 10.1109/JIOT.2016.2584538

28. Gazis, V., A. Leonardi, K. Mathioudakis, K. Sasloglou, P. Kikiras, and R. Sudhaakar. 2015. Components of fog computing in an industrial internet of things context. In 12th Annual IEEE International Conference on Sensing, Communication, and Networking - Workshops (SECON Workshops), (June 2015) 1–6

29. Datta, S.K., C. Bonnet, and J.Haerri. 2015. Fog computing architecture to enable consumer centric internet of things services. In International Symposium on Consumer Electronics (ISCE), (June 2015), 1–2.

30. Deng, R., R. Lu, C. Lai, T.H. Luan, and H. Liang. 2016. Optimal workload allocation in fog cloud computing towards balanced delay and power consumption. IEEE Internet of Things Journal PP(99): 1–1.

31. Hassan, M.A., M. Xiao, Q. Wei, and S.Chen. 2015. Help your mobile applications with fog computing. In 12th Annual IEEE International Conference on Sensing, Communication, and Networking - Workshops (SECON Workshops), (June 2015), 1–6. [34] Jalali, F., K. Hinton, R. Ayre, T. Alpcan, and R.S. Tucker. 2016. Fog computing may help to save energy in cloud computing. IEEE Journal on Selected Areas in Communications 34(5): 1728–1739.

32. Hou, X., Y. Li, M. Chen, D. Wu, D. Jin, and S. Chen. 2016. Vehicular fog computing: A viewpoint of vehicles as the infrastructures. IEEE Transactions on Vehicular Technology 65(6): 3860–3873.

33. Richard Hill, Laurie Hirsch, Peter Lake and Siavash Moshiri, "Guide to Cloud Computing: Principles and Practice" Springer London Heidelberg New York Dordrecht ISBN: 978-1-4471-4603-2 DOI 10.1007/978-1-4471-4603-2 2013

34. John W. Rittinghouse, James F. Ransome, "Cloud Computing: Implementation, Management, and Security" CRC Press, 2017 ISBN: 135161536X, 9781351615365 (2017)