A Survey On: A Measurement-based Analysis of the Energy Consumption of multiple Components of Data Center Servers on Cloud

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ABSTRACT
Data Centers are integrated facilities that house computer systems for cloud computing and have been widely deployed in large companies such as Amazon, Google, Microsoft or Yahoo. So the Energy Consumption by Servers is a growing issue in Data Centers. There are different components which offer more power and energy utilization, such as CPU, Disk, and Network interface. There are different techniques to measure the power and energy consumption of multiple components. Here CPU, Disk and Network interface energy consumption is measured based on load. Load increases as the number of client increases. Estimation of the power and energy consumption of Data Center Server Components helps to predict and optimize the energy consumed by an application.

General Terms
Cloud Computing.

Keywords
CPU, Data Centers, Disk, Energy measurement, Network.

1. INTRODUCTION
Cloud Computing offers utility-oriented IT services to users. Cloud Computing represents the possibility of outsourcing computational services without incurring amortization costs, scaling up or down the required resources to match the demand and in a pay-as-you-go way. The popularization of Cloud Computing has raised concerns over the energy consumption that takes place in data centers. Cloud Computing delivers Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS), which are made available to consumers as subscription-based services under the pay-as-you-go model. Clouds aim is to drive the design of the data centers by architecting them as network of virtual services so that users can access and deploy applications from anywhere in the world on demand at competitive costs depending on their Quality of Service requirements [1] [4].
Data Center plays a pivot role in Cloud Computing, and are consuming a significant amount of energy. A significant amount of power is consumed even when the server is idle. So the energy consumption of the data centers has become an essential problem. To manage multiple applications in a data center creates the challenge of on-demand resource provisioning and allocation in response time-varying workloads. Data centers are expensive to maintain and are also unfriendly to the environment [4[[6].

Servers are like puzzles where each one of its pieces has its own power consumption. At the same time, the global power consumption of an each one of these pieces is not constant, it depends on stress. Depending on the amount of accesses to disk, to memory, amount of data send to and receive from the network and on the amount of processing, the power required by CPU, Disk and Network are measured.

Central Processing Unit (CPU) is a processor, which organizes and processes the data and instructions received from the input source. It is responsible for manipulation of data. It has been traditionally considered that the CPU is responsible for most of the power being consumed in a server, and this power consumption increases linearly with the load. Although the power consumed by the CPU is significant, the power incurred by other elements of the server, such as Disk and Network interface cards are not negligible. The power due to memory is considered as part of the other components' consumption.

The rest of the paper is organized as follows. Section 2 provides information about related works. Section 3 describes the methodologies. Section 4 describes Modeling of Energy Measurement. Section 5 concludes the paper.

2. RELATED WORK
There is a large body of work in the field of modeling server power consumption and its components, both theoretical and empirical. The energy consumption of servers has been assumed as linear, where consumption depended mainly on CPU and linearly on its utilization [1][2][.

Different methods available to reduce energy with reduced clock speed, such as reducing the voltage or using reversible or adiabatic logic. Consider three types of scheduling algorithms. (1)Unbounded-delay perfect-future (OPT), (2) Bounded-delay limited-future (FUTURE), and (3) Bounded-delay limited-past (PAST). These algorithms adjust the CPU clock speed at the same time that scheduling decisions are made, with the goal of decreasing time wasted in the idle loop while retaining interactive response [2].

Unbounded-delay perfect-future (OPT) takes the entire trace, and stretches the run times to fill the idle times. Power savings were limited by the minimum speed, achieving the maximum possible savings over the period. This algorithm is impractical and undesirable. It is impractical because it requires perfect future knowledge of the work to be done over the interval. It is undesirable because it produces large delays in runtimes of individual jobs without regard to the need for effective response to real time events such as user keystrokes or network packets [2].

FUTURE is similar to OPT, except it peers into the future only a small window and optimizes energy over that window, while never delaying work past the window. It is assumed that all idle time in the next interval can be eliminated, unless the minimum speed of the CPU is reached. FUTURE is impractical, because it uses future knowledge. It is desirable, because no real time response is ever delayed longer than the window [2].

PAST is practical version of FUTURE. It looks a fixed window into the past and assumes the next window will be like the previous one [2].

Consider frequency in the analysis [3]. First consider CPU power utilization, which depends on the number of working cores, the CPU frequency and the CPU load. Energy consumption with a single working core at constant frequency can be closely approximated by a linear function of the CPU load. The energy consumption for a fixed CPU load is minimized by using the highest number of cores and the lowest frequency.

The energy consumption for reading and writing depends on the CPU frequency and the I/O block sizes. While energy consumption due to reading is not affected by block size but barely affected by the CPU frequency, where as writing increases with the block size [3].

The energy consumption and efficiency of Network interface card, in transmission and reception depends on the CPU frequency, the packet size and the transmission rate [3].

3. METHODOLOGY

The measurement techniques used to characterize the power consumption of CPU activity, Disk access and Network activity are based on frequency and load.

Total energy consumption is a sum of all the components energy consumption.

Total EC= $\mathbf{E_{CPU} + E_D + E_N}$

Aim of the proposed system is to estimate the energy consumed by Data Center Server deployed on Cloud, by measuring the usage of different server components energy consumption.

3.1 Collecting System Data

One prerequisite is the windows machine. Joulemeter is used to measure the load on CPU and load on Disk. Server is connected to this tool to obtain the energy values with respect to the number of clients. Result will be in watts.

3.2 CPU

In order to evaluate the CPU power consumption benchmark application is used. Start with lowest frequency and then increase gradually. And also starting with maximum load and then decreasing the load gradually.

Take different samples. Zero load is not possible as there is always going to be load in the system due to operating system. Use time slots for the time measurements. The measured values of load and power in each timeslot are used to obtain a curve.Estimate the CPU power consumption by subtracting Baseline consumption.

3.3 Disks

The power consumption of the hard drive is evaluated based on reading and writing operation. In both read and writeoperation, record the total power and time consumed in each one of these operations. Estimate the Disks power consumption by subtracting Baseline and CPU power consumption.

3.4 Network

There are several aspects that consider relevant in order to characterize the impact of the NIC on the total powerconsumption of a server. Here considering client server script to calculate the energy consumption by network interface.

In order to send and receive data, one computer system should act as a server(sender) and other as a client (receiver). In order to isolate the consumption from the network, subtract Baselineand CPU consumption from the measurement.

4. MODELING OF ENERGY MEASUREMENT

Aim of the proposed system is to estimate the energy consumed by Data Center Server deployed on Cloud, by measuring the usage of different server components energy consumption.

4.1 Devices and setup

In order to monitor the power used by a server during the different experiments Joulemeter is used, which is able to measure the total power used by the server. Fig 1 shows schematic representation of the setup used and the components under testing. In order to take measurements server is being connected to Joulemeter.

Experiment is done for two different scenarios. That is one with network connection and other is without network connection. Power utilization increases with the load (Clients) in both the cases.

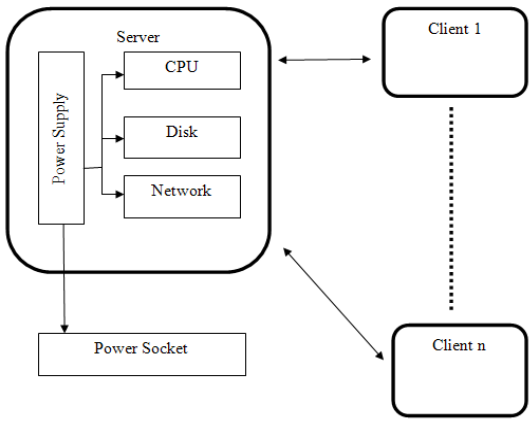

Fig 1: Schematic representation of a system

Here server contains components such as CPU, Disk, Monitor and Network, whose power utilization can be estimated and power supply port is connected to power socket. There is n number of clients and these are connected to server. Request from client and reply from server will be taken place between server and clients. Based on time energy consumption will be estimated using Joulemeter.

4.2 Joulemeter

A software tool that estimates the power consumption of the computers is known asJoulemeter. It tracks computer resources, such as CPU utilization, screen brightness and estimates the power usage.

Computation of energy costs have become important, because they directly impact the power provisioning cost for computing infrastructures, the operating expense of data centers and enterprise buildings and also battery life for laptops and mobile devices. The Joulemeter project focuses on following aspects related to energy optimization:

4.2.1 Modeling
Joulemeter estimates the energy usage of a virtual machine, a computer server or software application.It impacts the power management of various components such as the CPU, Screen, Memory and Storage on total power use.

4.2.2 Optimization
Joulemeter helps to improve power provisioning and consumption costs in various scenarios ranging from data centers, enterprise computing and battery operated machines.

4.3 CPU
Here power utilization observed is the sum of the baseline power consumption plus the CPU power consumption. Tune the load by using two or more clients. Fig 2 shows how load is being generated to the server.

To obtain the power utilization by CPU, subtract baseline estimation from CPU. Energy utilization increases with the number of clients.

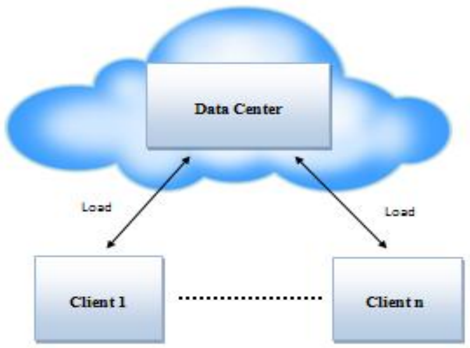

Fig 2: Load generation

4.4 Disks
To characterize disk power and energy consumption, consider disk input-output operations. Disks power consumption is small in all cases but it is not negligible with respect to the baseline consumption. To obtain the power utilization by Disk, subtract CPU estimation from Disk.

4.5 Network
To characterize the energy utilization by network activity, run server script in one system and client script in another system. Connect server system to Joulemeter and start this tool to obtain the values. Subtract CPU and Disk energy values from Network value. This gives the energy consumption during network activity. Fig 3 gives the energy versus load graph.

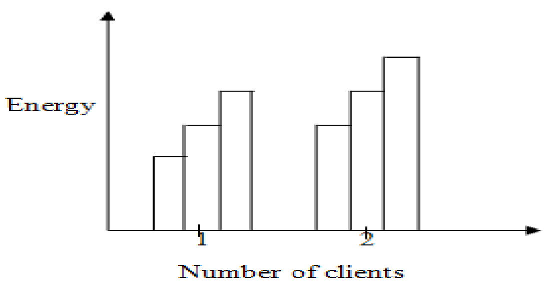

Fig 3: Energy versus Load Graph

5. ACKNOWLEDGMENTS
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6. CONCLUSION
This paper presents measurement-based analysis of energy consumption of multiple components in the data center servers. Components may be Disks, CPU or Network interface. Here energy consumption of CPU, Disks, Network interface is discussed based on load. CPU has largest impact on energy consumption among all the three components. Disks input and output is the second larger contributor to power consumption. And finally NIC activity is responsible for small but not negligible fraction of power consumption.

Measurement of energy utilization by server components can help to predict the best server by analyzing the estimated values and minimization of cost can be achieved and also user can known in advance about the energy utilization of each component to know performance of a system.

In future it is possible to evaluate energy consumption by different servers on different hardware configuration. It helps to predict the best server which consumes less energy.By this, the one who willing to use the cloud server can select best server. In turn cost minimization can also be achieved.

7. REFERENCES
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