Analysis of Energy Consumption in Different Types of Networks for Cloud Environment

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Abstract: **Cloud computing is expected to become a common solution for deploying applications. Thanks to its capacity to leverage developers from infrastructure management tasks, thus reducing the overall costs and services' time to market. Cloud computing has recently emerged as a new paradigm for hosting and delivering services over the Internet. Cloud computing is attractive to business owners as it eliminates the requirement for users to plan ahead for provisioning and allows enterprises to start from the small and increase resources only when there is a rise in service demand.**

This paper is the systematic review of reviewed academic research published in the field of energy efficient cloud environment, and aims to provide an overview of a new idea of analyzing the energy consumption in different type of networks with different downloading /uploading speed and comparing the performance of networks regarding cloud computing.

Keywords- **Cloud computing, Infrastructure-as-a-service, Platform-as-a-service, Energy consumption models, Software-as-a-service**

I. INTRODUCTION

Cloud computing is the delivery of computing as a service rather than a product, whereby shared resources, software and information are provided to computers and other devices as a utility (like the electricity grid) over a network (typically the Internet). The shift in energy usage in a cloud computing model has received little attention. Through the use of large shared servers and storage units, cloud computing can offer energy savings in the provision of computing and storage services, particularly if the end user migrates toward the use of a computer or a terminal of lower capability and lower energy consumption. At the same time, cloud computing leads to increases in network traffic and the associated network energy consumption. The issue of energy consumption in information technology equipment has been receiving increasing attention in recent years and there is growing recognition of the need to manage energy consumption across the entire information and communications technology (ICT) sector. If properly managed, cloud computing can potentially lead to overall energy savings. Cloud computing infrastructure is housed in data centers and has benefited significantly from these advances. Techniques such as, for example, sleep scheduling and virtualization of computing resources in cloud computing data centers improve the energy efficiency of cloud computing [10]. While it is important to understand how to minimize energy consumption in data centers that host cloud computing services, it is also important to consider the energy required to transport data to and from the end user and the energy consumed by the end-user interface.

II. METHODOLOGY

This review surveyed the existing literature using a principled and systematic approach: IEEE Xplore, Springer Link, Science Direct and Google Scholar, for the following keywords: energy efficient computing, how energy efficient cloud computing is, cloud computing, elastic computing, utility computing, Infrastructure as a Service, IaaS, Platform as a Service, PaaS, Software as a Service, SaaS, Everything as a Service, XaaS. The date range for this search was limited from 2010 until February 2012.

III. CLOUD SERVICE MODELS

Currently, cloud computing delivers Infrastructure, Platform, and Software as a Service (IaaS, PaaS, and SaaS) on a simple pay-per-use basis. Although some economic benefits of cloud computing are already universally accepted, the success of this paradigm is bound to the level of accessibility, control, reliability, and security assured to its users. Substitutability (e.g. alternative implementations, specialized interfaces The key of cloud computing lies in its component-based nature, i.e. reusability and runtime component replacements), extensibility, customizability and scalability. [7]

A. Software as a Service (SaaS)

SaaS refers to providing on demand applications over the Internet.. `SaaS comprises end-user applications delivered as a service rather than as traditional, on-premises software. The most commonly referenced example of SaaS is salesforce.com, which provides a customer relationship management (CRM) system accessible via the Internet. Software-as-a-Service (SaaS) is a model of software deployment whereby one or more applications and the computational resources to run them are provided for use on demand as a turnkey service. Its main purpose is to reduce the total cost of hardware and software development, maintenance, and operations. Security manage or control the underlying cloud infrastructure or individual applications, except or preference selections and limited administrative application settings.
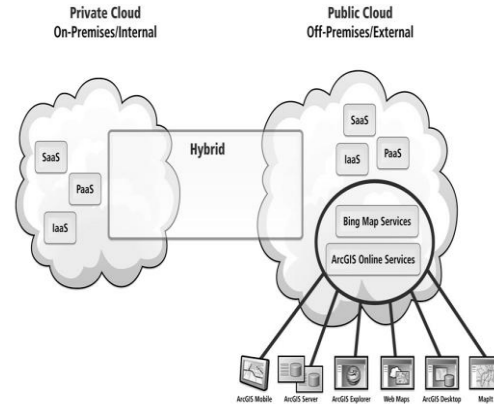

Fig.1: Cloud Service Models

B. Platform as a Service (PaaS)

PaaS refers to providing platform layer resources, including operating system support and software development frameworks. Examples of PaaS providers include Google App Engine, Microsoft Windows Azure and Force.com .[1]The Cloud Platform Service or the Platform as a Service (PaaS)delivers computing platforms as a service to sustain the cloud applications.

C. Infrastructure as a Service (IaaS)

1. IaaS refers to on-demand provisioning of infrastructural resources, usually in terms of VMs. The cloud owner who offers IaaS is called an IaaS provider. Examples of IaaS providers include AmazonEC2, GoGrid and Flexiscale.[1]
2. The Cloud Infrastructure Service or the Infrastructure as a Service (IaaS) provides IT infrastructures as a service over computer networks.
3. The *Cloud* provides virtualized computing hardware infrastructure in a manner similar to the public utilities, thus it is also termed as Infrastructure-as-a-Service (IaaS) or Utility Computing.
4. The main idea is to supply users with on-demand access to computing or storage resources and charge fees for their usage. In these models, users pay only for the resources they utilize .A key provider of this type of on-demand infrastructure is Amazon Inc. with its Elastic Compute Cloud (EC2). EC2allows users to deploy VMs on Amazon's infrastructure, which is composed of several data centers located around the world. To use Amazon's infrastructure, users deploy instances of pre-submitted VM images or upload their own VM images to EC2. The EC2 service utilizes the Amazon Simple Storage Service (S3), which aims at providing users with a globally accessible storage system. S3 stores the users' VM images and, as EC2, applies fees based on the size of the data and the storage time.

IV. LITERATURE SURVEY

There has been much search on making energy efficient cloud computing .The search from various papers returned over a number of results there has been energy consumption models defined to calculate the energy consumption in transport, storage and processing of data in cloud environment based on certain parameters: file download per hour, encoding per week[11].

A. MODELS OF ENERGY CONSUMPTION

The models described are based on power consumption measurements and published specifications of representative equipment [12], [13]. Those models include descriptions of the common energy-saving techniques employed by cloud computing service providers. The models are used to calculate the energy consumption per bit for transport and processing, and the power consumption per bit for storage. The energy per bit and power per bit are fundamental measures of energy consumption, and the energy efficiency of cloud computing is the energy consumed per bit of data processed through cloud computing. Performing calculations in terms of energy per bit also allows the results to be easily scaled to any usage level.

i. User Equipment

A user may use a range of devices to access a cloud computing service, including a mobile phone (cell phone), desktop computer, or a laptop computer. These computers typically comprise a central processing unit (CPU), random access memory (RAM), hard disk drive (HDD), graphical processing unit (GPU), motherboard, and a power supply unit. Peripheral devices including speakers, printers, and visual display devices are often connected to PCs. These peripheral devices do not influence the comparison between conventional computing and clouds computing and so are not included in the model. In our analysis, we assume that when user equipment is not being used it is either switched off or in a deep sleep state (negligible power consumption) [11].

ii. Data Centers

A modern state-of-the-art data center has three main components Vdata storage, servers, and a local area network (LAN) [12]. The data center connects to the rest of the network through a gateway router, as shown on the right-hand side of Fig. 1(a) and (b) [12]. The power

consumption data for each server was obtained by first calculating the maximum power using HP's power calculator then following the convention that average power use for midrange/high-end servers is 66% of maximum power, In the following, we outline the functionality of this equipment as well as some of the efficiency improvements in cloud computing data centers over traditional data centers [11].

iii. Network

In this section, we describe the corporate and Internet IP networks in greater detail and outline the functionality of the equipment in those networks.

a. *Corporate Network:* The corporate network comprises several Ethernet switches interconnected in a hierarchical configuration, as shown on the left-hand side of Fig. 1(b). A small Ethernet switch at the lower layer might aggregate traffic on one building floor, and several higher layer switches aggregate traffic from buildings or campuses. The energy EC required to transport one bit from the data center to a user through a corporate network is

$$E_C = 3 \times 3 \times \left(\frac{P_{les}}{C_{les}} + \frac{3P_{es}}{C_{es}} + \frac{P_g}{C_g} \right)$$

Where Pes, Ples, and Pg are the powers consumed by the Ethernet switches, small Ethernet switches, and data center gateway routers, respectively. Ces, Cles, and Cg are the capacities of the corresponding equipment in bits per second [11].

b. *Internet:* The access network is modeled as a PON. The energy consumption of the access network is largely independent of traffic volume. Thus the energy EI required to transport one bit from a data center to a user through the Internet is

$$E_I = 6 \left(\frac{3P_{es}}{C_{es}} + \frac{P_{bg}}{C_{bg}} + \frac{P_g}{C_g} + \frac{2P_{pe}}{C_{pe}} + \frac{2 \times 9P_c}{C_c} + \frac{8P_w}{2C_w} \right)$$

Where Pes, Pbg, Pg, Ppe, Pc, and Pw are the powers consumed by the Ethernet switches, broadband gateway routers, data center gateway routers, provider edge routers, core routers, and WDM transport equipment, respectively. Ces, Cbg, Cg, Cpe, Cc, and Cw are the capacities of the corresponding equipment in bits per second [11].

B. ANALYSIS OF CLOUD SERVICES

i.   Storage as a Service

The per-user power consumption of the storage service Pst , calculated as a function of downloads per file per hour, is.

$$P_{st} = \frac{B_d D}{3600} \left(E_T + \frac{1.5 P_{st,SR}}{C_{st,SR}} \right) + 2B_d \frac{1.5 P_{SD}}{B_{SD}}$$

Where Bd (bits) is the average size of a file and D is the number of downloads per hour. Pst;SR is the power consumption of each content server and Cst;SR (bits per second) is the capacity of each content server. The power consumption of hard disk arrays (cloud storage) is PSD and their capacity is BSD (bits).
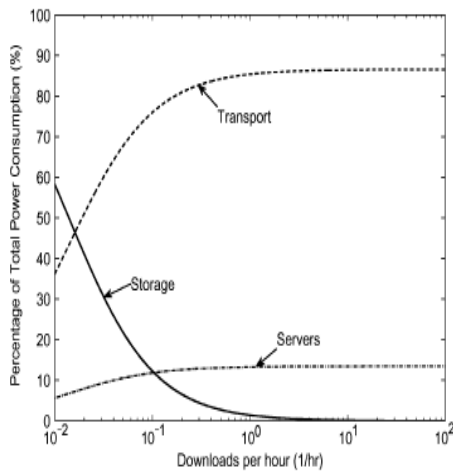

Fig. 2: Percentage of total power consumption of transport, storage and servers of a public cloud storage service as a function of download rate

ii.   Software as a Service

The per user power consumption Psf of the software service, including the terminal, as a function of the bit rate A (bits per second) between each user and server is

$$P_{sf} = P_{sf,PC} + \frac{1.5 P_{sf,SR}}{N_{sf,SR}} + 2B_d \frac{1.5 P_{SD}}{B_{SD}} + AE_T$$

where Psf ;PC is the power consumption of the user's terminal, Psf ;SR is the power consumption of the server, PSD is the power consumption of the hard disk arrays, Nsf ;SR is the number of users per server, and BSD is the capacity of the hard disk arrays. As with the storage service, the multiplication by a factor of 2 in the third term accounts for the power requirements for redundancy in storage and the multiplication by a factor of 1.5 for data center equipment (second and third terms) accounts for the energy consumption in cooling as well as other overheads.

iii.   Processing as a Service

We calculate the per-week energy consumption of the processing service as a function of the number of encodings per week N. The per-user energy consumption (watt hours) Eps of the processing service, including the user's PC, is

$$E_{ps} = 40 P_{ps,PC} + 1.5 N T_{ps,SR} P_{ps,SR} + 168 A E_T$$

Where Pps; PC is the power consumption of the user's laptop, Pps; SR is the power consumption of the server, and Tps; SR is the average number of hours it takes to perform one encoding. The user's PC is used on average 40 h/week for common office tasks (factor of 40 in first term). A factor of 1.5 is included in the second term to account for the energy consumed to cool the computation servers, as well as other overheads. In the third term, A is the per-user data rate (bits per second) between each user and the cloud, ET is the per-bit energy consumption of transport, and the factor of 168 converts power consumption in transport to energy consumption per week (watt hours).
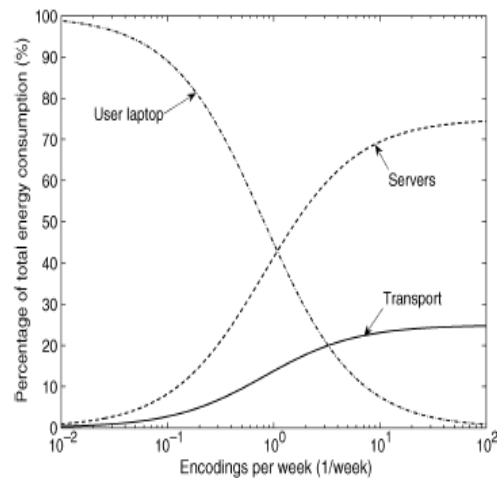

Fig. 3: Percentage of total power consumption of transport, storage and service of a public cloud processing service as a function of encodings per week

V.   CONCLUSION AND FUTURE SCOPE

As from all the papers reviewed above we conclude that there have been continuous improvements in the energy efficiency of equipment as new generations of technology come on line. This has led to exponential improvements over time in the energy efficiency of servers, storage equipment as well as routers and switches.

The novelty in our review paper is this, energy consumption in transport, storage and processing may be varying if different types of networks are considered. Different types of networks , here could be referred as networks with varying speeds i.e. with different download/upload speed according to which files download per hr varies and thus energy consumption can be analyzed and compared and based on this performance one can conclude that what network better suits to cloud computing in terms of energy efficiency.

The analysis in previous sections was based on state-of the-art technology in 2011. The future scope of this review paper is that the theoretical concept described in the conclusion can be implemented with some new and different parameters such as effect of encryption and other security methods on data.

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