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CLOUD COMPUTING: BALANCING ENERGY IN PROCESSING, STORAGE, AND TRANSPORT

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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, Energy consumption models

1. INTRODUCTION

Cloud computing refers to the provision of computational resources on demand via a computer network, such as applications, databases, file services, email, etc. In the traditional model of computing, both data and software are fully contained on the user's computer; in cloud computing, the user's computer may contain almost no software or data (perhaps a minimal operating system and web browser only), serving as little more than a display terminal for processes occurring on a network of computers far away. Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provides interactions. Cloud computing provides computation, software, data access, and storage services that do not require end-user knowledge of the physical location and configuration of the system that delivers the services. Parallels to this concept can be drawn with the electricity grid, where end-users consume power without needing to understand the component devices or infrastructure required to provide the service. Cloud computing describes a new supplement, consumption, and delivery model for IT services based on Internet protocols, and it typically involves provisioning of dynamically scalable and often virtualized resources It is a byproduct and consequence of the ease-of-access to remote computing sites provided by the Internet. This frequently takes the form of web-based tools or applications that users can access and use through a web browser as if they were programs installed locally on their own computers.

Typical cloud computing providers deliver common business applications online that are accessed from another Web service or software like a Web browser, while the software and data are stored on servers. Most cloud computing infrastructures consist of services delivered through common centers and built-on servers. Clouds often appear as single points of access for consumers' computing needs. Commercial offerings are generally expected to meet quality of service (QoS) requirements of customers, and typically include service level agreements (SLAs).

The increasing availability of high-speed Internet and corporate IP connections is enabling the delivery of new network-based services. While Internet-based mail services have been operating for many years, service offerings have recently expanded to include network-based storage and network-based computing. These new services are being offered both to corporate and individual end user. Services of this type have been generically called cloud computing services. The cloud computing service model involves the provision, by a service provider, of large pools of high performance computing resources and high-capacity storage devices that are shared among end users as required. There are many cloud service models, but generally, end users subscribing to the service have their data hosted by the service, and have computing resources allocated on demand from the pool. The service provider's offering may also extend to the software applications required by the end user. To be successful, the cloud service model also requires a high-speed network to provide connection between the end user and the service provider's infrastructure.

Cloud computing potentially offers an overall financial benefit, in that end users share a large, centrally managed pool of storage and computing resources, rather than owning and managing their own systems. Often using existing data centers as a basis, cloud service providers invest in the necessary infrastructure and management.

2. 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.

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.

a) 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].

b) Data Centers

A modern state-of-the-art data center has three main components data storage, servers, and a local area network (LAN) [12]. The data center connects to the rest of the network through a gateway[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].

c) 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. 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

$$E_c=3 \text{ x } 3\ (P_{les}/C_{les} + 3P_{es}/C_{es} + P_g/C_g)$$

Where P_{es}, P_{les}, and P_g are the powers consumed by the Ethernet switches, small Ethernet switches, and data center gateway routers, respectively. C_{es}, C_{les}, and C_g are the capacities of the corresponding equipment in bits per second [11].

d. 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

$$E_1=6(3P_{es}/C_{es}+P_{bg}/C_{bg}+P_g/C_g+2P_{pe}/C_{pe}+2\text{x}9P_c/C_c+8P_w/C_w)$$

Where P_{es}, P_{bg}, P_g, P_{pe}, P_c, and P_w 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. C_{es}, C_{bg}, Cg, C_{pe}, C_c, and C_w are the capacities of the corresponding equipment in bits per second [11].

3. CLOUD SERVICE MODELS

We focus our attention on three cloud services - storage as a service, processing as a service and software as a service.

A. Software as a Service

Consumer software is traditionally purchased with a fixed upfront payment for a license and a copy of the software on appropriate media. This software license typically only permits the user to install the software on one computer. When a major update is applied to the software and a new version is released, users are required to make a further payment to use the new version of the software. Users can continue to use an older version, but once a new version of software has been released, support for older versions is often significantly reduced and updates are infrequent. With the ubiquitous availability of broadband Internet, software developers are increasingly moving towards providing software as a service. In this service, clients are charged a monthly or yearly fee for access to the latest version of software. Additionally, the software is hosted in the cloud and all computation is performed in the cloud. The client's PC is only used to transmit commands and receive results. Typically, users are free to use any computer connected to the Internet. However, at any time, only a fixed number of instances of the software are permitted to be running per user. One example of software as a service is Google Docs. When a user exclusively uses network- or Internet-based software services, the concept is similar to a "thin client" model, where each user's client computer functions primarily as a network terminal, performing input, output, and display tasks, while data are stored and processed on a central server. Thin clients were popular in office environments prior to the widespread use of PCs.

B. Storage as a Service

Through storage as a service, users can outsource their data storage requirements to the cloud. All processing is performed on the user's PC, which may have only a solid state drive (e.g., flash-based solid-state storage), and the user's primary data storage is in the cloud. Data files may include documents, photographs, or videos. Files stored in the cloud can be accessed from any computer with an Internet connection at any time. However, to make a modification to a file, it must first be downloaded, edited using the user's PC and then the modified file uploaded back to the cloud. The cloud service provider ensures there is sufficient free space in the cloud and also manages the backup of data. In addition, after a user uploads a file to the cloud, the user can grant read and/or modification privileges to other users. One example of storage as a service is the Amazon Simple Storage service.

C. Processing as a Service

Processing as a service provides users with the resources of a powerful server for specific large computational tasks. The majority of tasks, which are not computationally demanding, are carried out on the user's PC. More demanding computing tasks are uploaded to the cloud, processed in the cloud, and the results are returned to the user. Similar to the storage service, the processing service can be accessed from any computer connected to the Internet. One example of processing as a service is the Amazon Elastic Compute Cloud service. When utilizing a processing service, the user's PC still performs many small tasks and is consequently required to be more powerful than the "thin client" considered in the software service. However, the user's computer is not used for large computationally intensive tasks and so there is scope to reduce its cost and energy consumption, relative to a standard consumer PC, by using a less powerful computer.

	Software as a Service	**Storage as a Service**	**Processing as a Service**
Location of Processing	Gloud	Client	Short task at Client, Large task in Gloud
Location of Storage	Gloud	Gloud	Client
Function of Transport	Transmit commands and Receive results	All Files/Documents	File for large tasks

Table-1: Summary of Gloud Services

4. ANALYSIS OF GLOUD SERVICES

a) Storage as a Service

The per-user power consumption of the storage service P_{st} , calculated as a function of downloads per file per hour, is

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

Where B_d (bits) is the average size of a file and D is the number of downloads per hour. P_{st}, S_R is the power consumption of each content server and C_{st}, S_R (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).

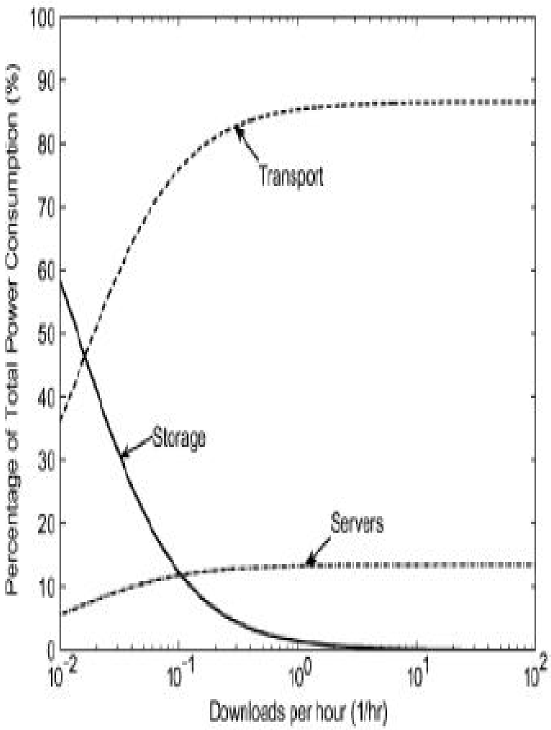

Figure-1: Percentage of total power consumption of transport, storage and servers of a public cloud storage service as a function of download rate

b) Software as a Service

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

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

where P_{sf}, P_C is the power consumption of the user's terminal, P_{sf} , S_R is the power consumption of the server, P_{SD} is the power consumption of the hard disk arrays, N_{sf}, S_R is the number of users per server, and B_{SD} 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.

c) 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) E_{ps} of the processing service, including the user's PC, is

$$E_{ps} = 40P_{ps,PC} + 1.5NT_{ps,SR}P_{ps,SR} + 168AE_T$$

Where P_{ps}, P_C is the power consumption of the user's laptop, P_{ps}, S_R is the power consumption of the server, and T_{ps}, S_R is the average number of hours it takes to perform one encoding. The user's P_C 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).

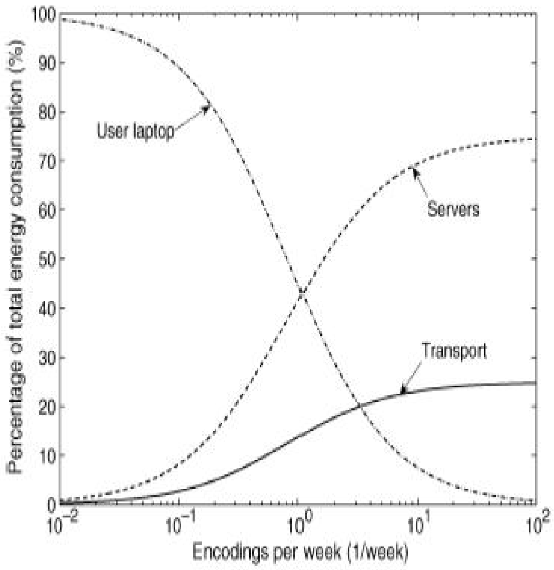

Figure-2: Percentage of total power consumption of transport, storage and service of a public cloud processing service as a function of encodings per week

CONCLUSION

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 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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