Analyzing Commercial Aspects and Security Concerns Involved in Energy Efficient Cloud Computing

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Abstract—— Cloud computing is the one of the scorching topic of research today and expanding exponentially. Today any information is available anywhere in the world at any time. But few years ago, this was not the case. Cloud refers to network or Internet. Cloud computing provides with the services over public and private networks at remote locations. Popular applications like VPN, WAN executes on cloud. Moving data and applications to Internet and access to them through services gives some advantages to organizations. Although today there are still some doubts and reservations towards it. The central theme of this research paper is to analyze the working of cloud computing and elaborating its applications in commercial sector. The paper also elaborates different security risks involved in cloud computing.

Keywords— Cloud Computing; Cloud security; IaaS; PaaS; SaaS.

I. INTRODUCTION

Today it has been made possible that people are consulting their mail online through webmail clients, working on collaborative documents using web browsers and creating virtual albums. People are running applications on servers and even storing their crucial data on servers rather than on their systems. All this has been made possible because of cloud computing. The name cloud computing [1, 2, 4] has been given because of a metaphor about internet as user can see the entire system as a cloud but can view what's inside it.

➢ The IT encyclopedia whatis.com explains cloud computing as a general term for anything that involves delivering hosted services over internet. The three main features that distinguish cloud from traditional hosting are

● It is available to be sold on demand as required, by minute or by hour.

● It is elastic as one can use as much service as they desire at any time.

● All this provided service is managed by the provider.

➢ IEEE defines cloud computing as a model in which information is stored permanently on servers on internet and temporarily cached on clients.

➢ Wikipedia illustrates cloud computing as computation, data access, software and storage services which are not confined to end user knowledge of the physical location and configuration of the system that delivers services.

So, it can be concluded that cloud computing is a computational model based on consumption of resources, applications and hardware offered on internet and used on demand.

II. MODELS OF CLOUD COMPUTING

The two broad categories in which working models of cloud computing can be classified are Deployment models and Service models [3, 4].

A. Deployment Models

Deployment models are further classified into four different categories based on type of access to the cloud (Fig. 1), i.e., how the cloud is located.
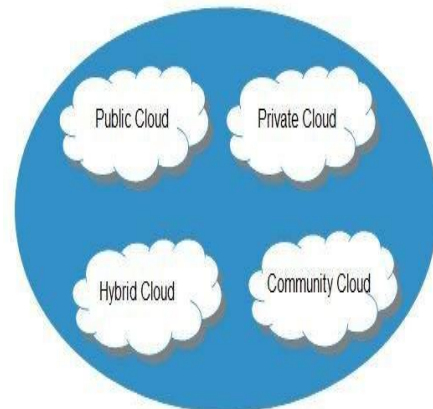

Fig. 1 Types of Deployment models.

➢ *Public cloud*
The public cloud (Fig. 2) provides general public to allow easy access to systems and services. Because of its openness, this cloud is less secure. The major IT giants like Google, Amazon and Microsoft offer cloud services via Internet [4].
Advantages
● Cost effective
● Reliability
● Flexibility

- Location Independence
- Utility Style Costing
- High Scalability
  Disadvantages
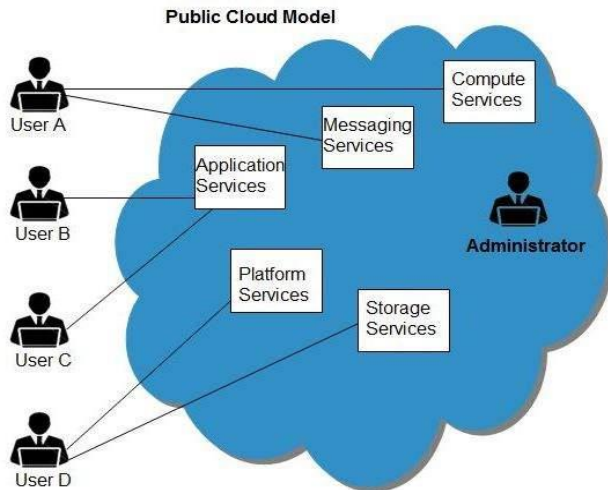- Low Security
- Less customizable

Fig. 2. Infrastructure of public cloud model.

➢ *Private cloud*

The private cloud (Fig. 3) grants permission to access systems and services only within an organization. It is more secured because of its private nature [4].
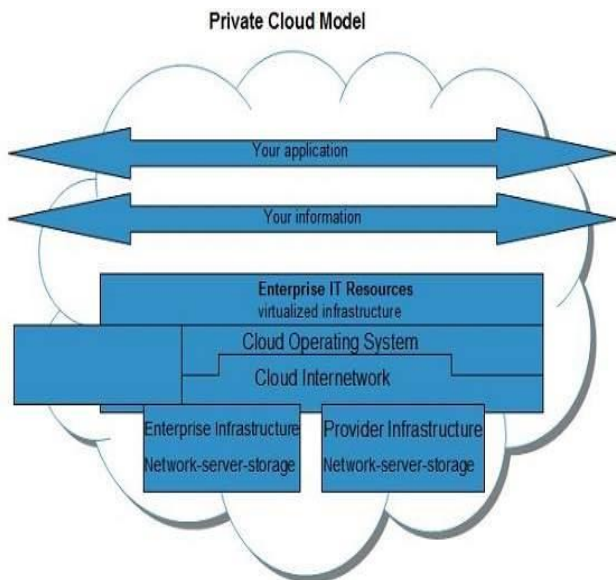

Fig. 3. Private Cloud Model.

Advantages
- High security and privacy
- More Control
- Cost and energy efficiency
- Improved reliability
Disadvantages

- Restricted area of operation
- High priced
- Limited Scalability
- Additional skills required for maintain cloud

➢ *Community Cloud*

Community cloud [4] permits to access systems and services by group of organizations as shown in Fig. 4.
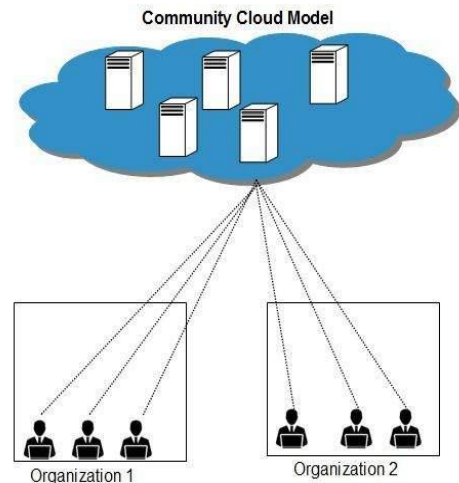

Fig. 4. Model of community cloud.

Advantages
- Cost effective
- Sharing among organizations
- Security
  Disadvantages
- Data is easily accessible to other users
- Difficult to allocate responsibilities of security, cost and governance.

➢ *Hybrid Cloud*

Hybrid cloud (Fig. 5) is a mixture of public and private cloud. In this all important and critical activities are performed using private cloud and all non-critical activities are performed using public cloud.
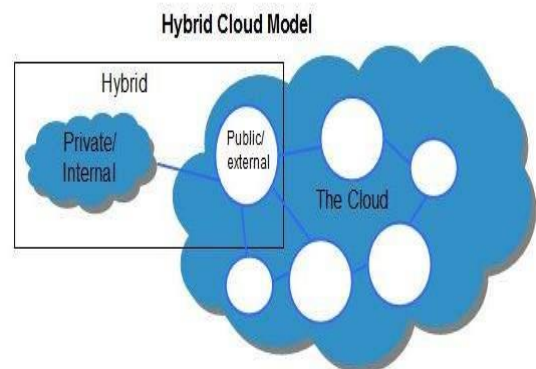

Fig. 5. Hybrid cloud model.

Advantages
- Scalability

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- Flexibility
- Cost efficiency
- Security

Disadvantages

- Networking issues
- Security Compliance
- Infrastructure dependency

B. Services Models

The service models in cloud computing are categorized into three categories (Fig. 6).

➢ Infrastructure-as–a-Service (IaaS)
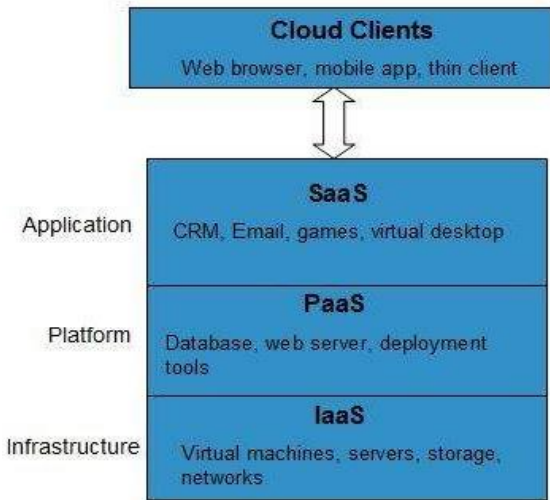➢ Platform-as-a-Service (PaaS)
➢ Software-as-a-Service (SaaS)

Fig. 6. Shows three different service models.

IaaS offers access to fundamental resources such as physical and virtual machines, virtual storage etc.

PaaS provides an efficient runtime environment for running different applications, development and deployment tools.

SaaS model focuses on providing software applications as a service to end-users.

Anything-as-a-Service (XaaS) is yet another service model, which includes Network-as-a-Service, Business-as-a-Service, Identity-as-a-Service, Database-as-a-Service or Strategy-as-a-Service.

III. CHARACTERISTICS OF CLOUD COMPUTING

There are four key characteristics of cloud computing [4, 5]. They are shown in Fig. 7.

➢ On Demand Self Service - The biggest advantage of using cloud is that one can use web services and resources on demand. One can logon to a website from any geographical location on planet earth and can do this anytime.
➢ Broad Network Access - Cloud can be accessed anywhere because of the presence of internet.
➢ Resource Pooling - Cloud computing provides provision to share resources among multiple tenants simultaneously.

Users can share single physical instance of hardware, database and infrastructure.

➢ Rapid Elasticity - Cloud computing is a flexible technology. It offers to scale resources vertically or horizontally as required. The resources under use by different tenants are monitored by default.
➢ Measured Service - All aspects of cloud computing are monitored under this service. Optimizing resources, capacity planning, billing etc. depends on it.
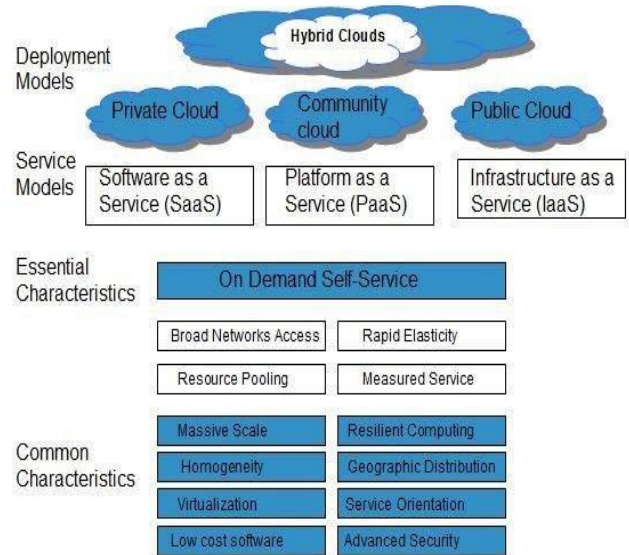

Fig. 7. Figure showing characteristics of cloud computing.

IV. THE OTHER SIDE OF THE COIN

It is a known fact, that every new technology has its own pros and cons and same is the case with cloud computing. The matter here to think over is that if the cloud is so good then why many firms are still hesitating in adopting it. Some of the reasons explored are stated as under [2, 3].

➢ Companies and organizations those have already invested heavily in setting up their own infrastructure and platform will definitely focus on utilizing their own assets to utmost potential rather than adopting for cloud.
➢ Often it is noticed that some enterprises have a complicated environment which makes it difficult for them to migrate to cloud or involve cloud computing into their current infrastructure.
➢ It is obvious that company will have less transparency on cloud as compared to any in-house infrastructure. The faith on the hosting provider has always been an issue for several enterprises.
➢ Often organizations have to go through certain compliance and strict regulations in the security concerns and due to certain regulatory requirements, they are unable to adopt cloud computing.

There has been a general talk among the people related to IT sector that cloud is good for every business and any application can adopt the cloud. But actually this is not the case as every company is not ready to integrate with different

cloud computing services available. There is a need to perform analysis of application and environment before adopting cloud. There are different perspectives for cloud adoption framework which are discussed as under.

➢ Business perspective – In this area the primary concern is to use technology in efficient and best possible manner.
➢ Platform Perspective – It focuses on the area to ensure that environment is architected in such a manner that all the expected levels of functionality are achieved.
➢ Maturity Perspective – It focuses on the concept that appropriate initial assessment is done and desired target state is achieved.
➢ People perspective – This area focuses on ensuring dynamic organizational structures and capability to operate and manage cloud based environment.
➢ Process perspective – This area focuses on the concept that processes are in place to implement, operate and manage cloud-based environment.
➢ Operations perspective – It focuses on the concept that cloud environment can be efficiently operated and managed.
➢ Security Perspective – It focuses on laying security within the cloud environment.

V. STORAGE ON CLOUD

The biggest roadblock linked with cloud is data storage and backup as data is most valuable asset for any organization and specially in case of public cloud, where data resides at remote vendor location and one do not have visibility of location, security and access. The efficient use of storage on cloud is serious matter that deserves attention.

One of the major roadblocks associated with Cloud is Data Storage and Backup because data is the most precious asset for any Enterprise and as while leveraging public cloud, data is going to be at cloud vendor location and we don't have the visibility of location, security and access. Let's discuss how cloud storage can be efficiently used. Everyone making use of cloud today is curious to know whether one can move their backups to cloud. Traditionally tapes and disks were used for backup. But today because of cost benefits and reliability companies are preferring cloud for storage.

But the point here to understand is that cloud cannot be ultimate destination to hold all of one's backup data. One has still to use tapes and disks which are instantly available to restore. All daily and weekly backups fall in this category. Cloud is preferred only where organizations have long term retention requirements which can have time span from one year to several years, based on compliance and legal agreements. Cloud is actually for backup data which is rarely accessed. Chances of getting restore is minimum due to following facts:

➢ Data out charges will apply for any restore done from cloud storage
➢ Network bandwidth needs to be planned and restore might take a long time (longer than disk) depending on the bandwidth.

➢ Frequent restore requests will increase the cost of backup solution and can also cause issues while customers are trying to meet their SLA's for critical applications (limited Network Bandwidth).

VI. COMMERCIAL OBJECTIVES OF CLOUD COMPUTING

There is no uncertainty in the fact that cloud computing is re-inventing the way information technology can quickly enable business outcomes. By the end of 2016, out of 1000 global companies, 50% would store customer sensitive data on cloud. It is paramount to set clear objectives for any organization to adopt an effective cloud computing program from top of the line (productivity gains) to bottom line (operational expenses). In addition to this, cloud computing provides many other benefits which are often overlooked. The five key objectives are stated as under [1, 3].

➢ Increased focus on business

Business agility and capability are two factors which organizations often skip out while setting their cloud computing objectives. Business growth and productivity gets ensured when focusing on core business while leaving rest of the cloud service. This also facilitates scalability of resources for business needs to provide a better user experience through robust cloud services.

➢ Faster Time-to-Market

Along with providing network and computing resources, cloud platforms also provide enterprise frameworks like authorization, authentication, user interface and workflow. As no time is wasted in setup, these frameworks reduces the overall time-to market

➢ Increased business agility

Cloud platforms authorize business users to bring operative changes to functionality through configuration. This causes reduction in dependency on development teams and help making business agile.

➢ Reduced operational costs

Because of reduced overhead costs and low maintenance, seamless integration of applications takes place in cloud enabled environments. Organizations are able to reduce hardware, software and licensing costs because cloud operates on the model of pay-as-you-use. This results in minimum deployment cost and almost zero expenditure on capital.

➢ Lower development costs

Cloud computing minimizes total cost of ownership (TCO) as it provides faster time-to-market. Development of new capabilities can be designed and implemented because of reduced expenditure factor.

VII. SECURITY ISSUES IN CLOUD COMPUTING

A. Data breaches

Cloud too faces the same threats as conventional networks used to face. But because of huge amount of data stored on cloud, the security concerns become an attractive subject and needs to dealt very seriously. The impact of the damage depends upon the sensitivity of the data. Breaches related with health information, trade and intellectual property often proves to be more devastating. Whenever data breach takes place,

companies has to incur heavy fines and even face lawsuits. Indirect impacts like loss of goodwill can have long term impacts [6, 7].

B. Compromised Credentials and Broken Authentication

Data breach occurs because of weak passwords, poor certificate management and not enough strong keys. Organizations often allocate special permissions to their employees for performing tasks assigned to them. But these organizations often forget to change these passwords when employees leave the company. Authentication systems like OTP, phone-based authentication and smartcards make it difficult for hackers to log in with stolen passwords. Many programmers often commit mistake of writing credentials and cryptographic keys in the source code itself. Keys need to be well protected and it is advisable to change these security keys periodically. Also centralizing identity into a single repository has its own risks.

C. Hacked interfaces and APIs

APIs are offered by every cloud service today. The security of cloud services depends upon the security of API. Weak APIs and interfaces expose organizations to security issues like integrity, availability, confidentiality and accountability. APIs are most vulnerable because these are accessible from open internet [6].

D. Account hijacking

Attackers can eavesdrop on activities, modify data and manipulate transactions via cloud services. Many attacks can be launched by using cloud application. Organizations should deny the sharing of account credentials between users and services.

E. Malicious insiders

The insiders refer to the current or former employees of an organization. Any corrupt employee in cloud environment can destroy whole infrastructure and manipulate data. Organizations should control the entire encryption process. Effective monitoring and auditing administrator activities needs to be done essentially. Appropriate training is a critical factor for management to avoid mistakes [7].

F. Permanent data loss

As the cloud computing has been in existence since many years now, it has matured to a very strong and robust technology. Today the reports of permanent data loss because of provider error is very rare. But still malicious hackers are in continuous attempt to permanently delete data on cloud to harm businesses and moreover, cloud data centers are as vulnerable to natural calamities as any other facility. To ensure safety of critical data, cloud providers always recommends distribution of data and applications among multiple zones. Off-line storage and daily data backup are very important in cloud environments. Every time the burden of preventing data loss is not of cloud service provider. Suppose a customer encrypts his/her data before uploading it onto the cloud, then it is sole responsibility of the customer to protect his/her

encryption key. If key is lost, so is the data. Cloud service providers also needs to take care of compliance policies like how long organizations must retain audit records and other relevant documents [7, 8].

VIII. ENERGY EFFICIENCY IN CLOUD COMPUTING

Accomplishing service level agreements and achieving noteworthy savings in any data center are excellent economic inducement for data center operators. Cloud computing has changed the model of storing and managing data for real time, internet based and scalable applications and resources satisfying end user needs. The number of remote host machines are continuously increasing with the demand and are responsible for causing more power dissipation and power consumption. Amazon.com expenses at it data center (Fig. 8) amortized over 15-year period are mentioned as under.

- Cost and operation of server – 53% of total
- Energy related costs – 42% of total (Direct power consumption-19%, Cooling infrastructure-23%)
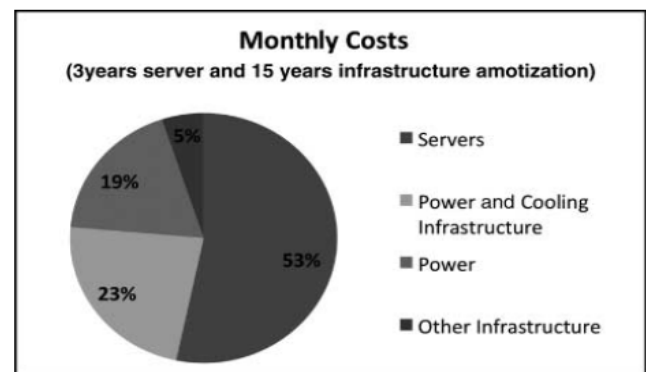

Fig. 8 Energy consumption at Amazon data center.

The best method to reduce the energy consumption at any data center is to make use of energy efficient hardware at the host side. International standard bodies like US Energy Star, European TCO Certification are responsible for rating energy efficient hardware. Electronic materials are more power efficient than common hard disk drives but are costly.

- SpeedStep®: It is manufactured by Intel and is a wireless technology capable of adjusting CPU power dynamically based on performance demand. It can change voltage and frequency on-the-fly saving additional power.
- PowerNow!™: It is manufactured by AMD and can efficiently manage power consumption promptly by controlling voltage and frequency independently. It has three operational modes namely High performance mode, Power saver mode and Automatic mode.
- Cool'n'Quite™: It is manufactured by AMD. It is responsible for controlling system fan, voltage and processor cores clock speed depending on system temperature.
- Demand Based Switching®: Intel's SpeedStep® technology's operations can be practically implemented more frequently by enabling more-granular demand based switching and on demand power to performance balance.

IX. CURRENT AND FUTURE ASPECTS OF CLOUD COMPUTING

Some fascinating facts about cloud computing are mentioned as under.

- It is observed that nearly one-half of the U.S. government agencies uses the cloud.
- Banking sector is the biggest segment to produce maximum activities within the cloud.
- Cloud computing market is expected to touch $106 billion by the end of 2016.
- 60% of IT decision makers trust the security of the cloud.
- Public cloud alone will experience a growth of 44% during next five years.
- For every 600 tablets and 1200 smartphones, a new server is added to the cloud.
- SaaS application will touch 67.4 billion by the end of 2016 making it largest cloud service category.
- The US Federal government saves $5.5 billion each year by shifting to the cloud.
- Nearly 90% of Microsoft's budget for R&D is utilized to improve security services and cloud computing.
- 80% of cloud adopters have reduced their IT related costs and expenditures.

- 75% of businesses have improved their service availability since they adopted cloud.
- 64% of businesses reduced their energy consumption and waste after shifting to cloud.
- The demand for professionals with cloud computing experience have increased 56%.
- Nearly 36% of business data is stored in cloud by the end of 2016.

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