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Open Cloud Computing with Fault Tolerance

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***Abstract*—**Cloud Computing (CC) has become one of the most talked about emerging technologies that provides powerful computing and large storage environments through the use of the Internet. Cloud computing provides different dynamically scalable computing resources as a service. It brings economic benefits to individuals and businesses that adopt the technology. In theory adoption of cloud computing reduces capital and operational expenditure on information technology. For this to be a reality there is need to solve some challenges and at the same time addressing concerns that consumers have about cloud computing. This paper looks at Cloud Computing in general then highlights the challenges of Cloud Computing and finally suggests solutions to some of the challenges.

***Keywords*—**Cloud Computing, SaaS, PaaS, IaaS, Internet.

I. Introduction

CLOUD COMPUTING (CC) is the buzz word for those who want to turn their desktops or mobile devices into virtually unimaginable powerful computing and large storage environments through the use of Internet. It provides the computing infrastructure (e.g. servers, storage), platforms (e.g. operating systems) and software (e.g. application programs) [1]. End users access desired resources through a browser and get data from cloud computing service providers without investing in maintaining their own data centres [2]. Cloud computing is driven by economic of scale. One of the main benefits is that end users are able to access computing resources on-demand for a fee through the Internet anywhere anytime. There are so many claims of what cloud computing can do. Cloud computing service providers promise that multiple end users are able to share information and collaborate on projects and/or documents in cloud [3]. The fee to pay for use of CC resources is affordable. End users only get CC resources scaled to their needs. The security of end user data is guaranteed. The CC infrastructure is very robust that CC resources will always be there all the time [4].

In this paper discussions of the definition of Cloud Computing and its characteristics is done in Section II, Cloud Computing Service Models is dealt with in Section III, Cloud Computing Deployment Models in Section IV, Challenges facing Cloud Computing in Section V, Suggested Solutions in Section VI and then Conclusion is given.

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II. Cloud Computing

In this section we discuss the definitions in [5], [6] and then the characteristics of cloud computing. In [6], Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources that is networks, servers, storage, applications, services, etc that can be rapidly provisioned and released with minimum management effort or service provider interaction. In [5], [7] it is a large-scale distributed computing paradigm that is driven by economic of scale, in which a pool of abstracted, virtualized, dynamically-scalable, managed computing power, storage, platforms and services are delivered on-demand to customers over the Internet. From these two definitions we can derive the characteristics of cloud computing. These are shown in Fig. 1. These characteristics apply to all clouds. Cloud computing service provider put together computing resources that are shared by billed multiple clients (Resource Pooling). The clients must be able to access the cloud through the Internet whenever they need a cloud service (Self Service, Internet Access). The use of cloud should be measured in order to be billed (Measured Usage). The resources released to a client must be proportional to client's needs at any given moment (Dynamically Scalable).

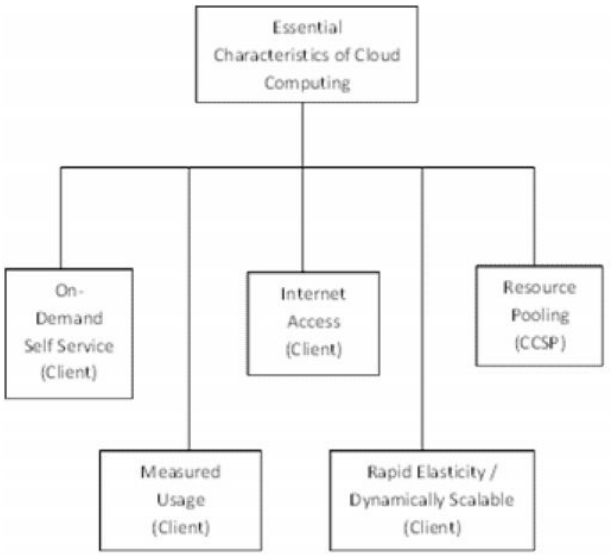

Fig. 1 Fundamental Characteristics of Cloud Computing

III. Cloud Computing Service Models

Cloud Computing provides services at different levels that are mainly classified in three categories as shown in Fig. 2. The cloud services are as follows: Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and then Software as a Service (SaaS) [8], [9]. Infrastructure services could be provisioning of storage and computing power. Some of companies that give such services are Amazon Web Services, BlueLock, Cloudscaling, OpSourse, etc. Platform services entail offering a high level integrated environment to develop, test and deploy custom applications. Companies like Appistry, AppScale, and Engine Yard are some of the platform service providers. Software services enable clients to access special purpose software through the Internet [10]. These applications could be e-mails, office applications, video, data processing, etc. Some of the application service providers are Abiquo, AccelOps, Akamai, Apprenda, etc.

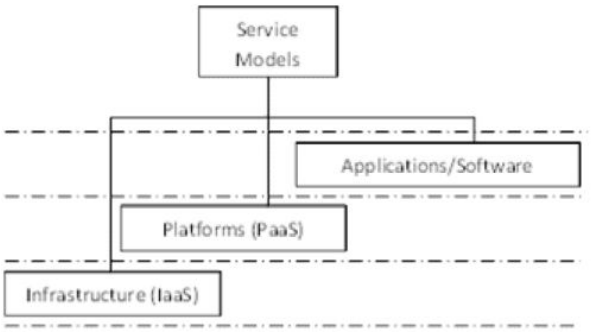

Fig. 2 Service Models of Cloud Computing

The billing of clients for the service provided is static or dynamic. Fig. 3 shows the modes of pricing.

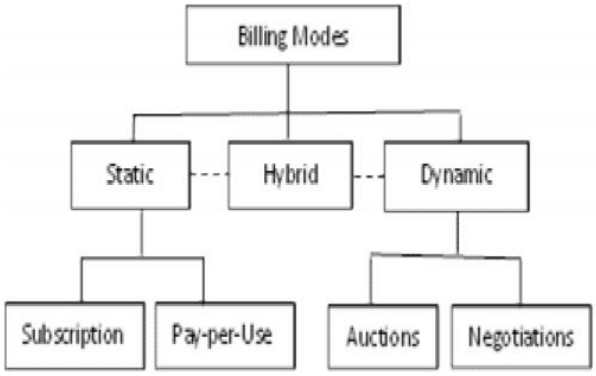

Fig. 3 Modes of Pricing

IV. Cloud Computing Deployment Models

The National Institute for Science and Technology (NIST) has defined four distinct cloud computing deployment models; private cloud, community cloud, public cloud, and hybrid cloud as shown in Fig. 4 [6], [11]. Public cloud model is the most commonly referred to as cloud computing. The physical resources are owned and operated by a third party Cloud Computing Provider (CCP). The provider services multiple clients that may consist of individuals or businesses utilizing these resources through the Internet. Services can be dynamically provisioned and are billed based on usage alone. Private cloud model describes computer services offered to multiple users in a single organization. The services are offered on demand from a distributed infrastructure. The cloud computing resources may be situated on or off-site. This model can be managed in-house or by a third party [11]. It addresses the security and privacy concerns that are inherent in other cloud computing models. Community cloud contains features of the public and private cloud models. The computing resources are utilized by multiple organizations. The infrastructure is only utilized by a group of organizations that are known to each other. These organizations are responsible for the operation of their own infrastructure. This model is best suited for organizations that share common requirements such as security or legal compliance policies [6]. It can be managed by the member organization(s) or by a third party provider. The hybrid cloud model employs aspects of the other cloud models. It is commonly used method of cloud deployment within a large organization. An organization may use internal resources in a private cloud to maintain total control over its proprietary data. It can then use a public cloud storage provider for backing up less sensitive information. Also use community cloud to share computing resources with other organizations that have similar needs.

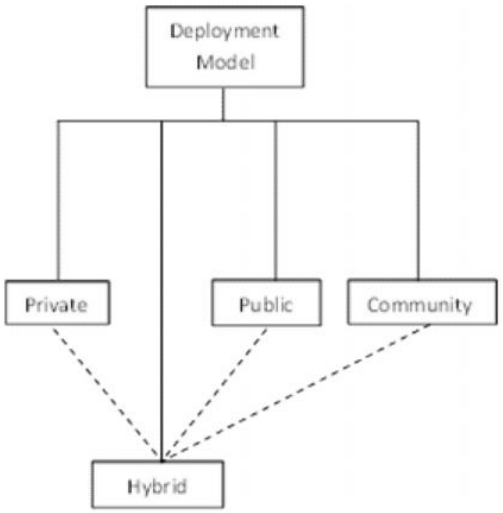

Fig. 4 Cloud Computing Deployment Models

V. Challenges of Cloud Computing

The cloud computing that most concern most organizations and individuals is the public cloud model. The physical resources are owned and operated by a third party Cloud Computing Provider (CCP). The data centres are located anywhere in the world as desired by the owner [12]. The organizations and individuals access these resources through the Internet. The Application Platform Interfaces (APIs) for

cloud computing are essentially proprietary and they have not been standardized [13]. This scenario brings the following challenges to cloud computing:

- Security\ Confidentiality issues
- Data\Vendor lock-in
- Fault tolerance
- Interoperability\Portability
- Recovery.

Security\Confidentiality issues are some of the main worries for the acceptance of cloud computing [14], [15]. There is need to assure users of safety of their data during transfer and storage. The transparency of the geographical location of where the data is stored and how it is protected is necessary to the user [12], [16]. The reason for this is that some countries' laws allow governments to have access to data stored within their jurisdiction [16]. Some insurance companies would require data to be in certain geographical areas. In reality the only valid concern of security in public cloud model is the safety of data during transfer and storage. The data is supposed to be secured from the cloud users, cloud providers and\or third party vendors that users rely on for security-sensitive software or configuration [4]. The guarantee of security becomes one step in making cloud computing acceptable.

Data\Vendor lock-in makes the choice of Cloud Computing Service Provider very difficulty. The price may be attractive but if later one is not satisfied with the service or pricing is no longer attractive it will be very difficult to move to the next provider. This is due to the fact that each service provider develops its own solution and avoids being open with it due to competition in the business space thus tying up users to their services [4], [6].

Relying on accessing services through the Internet requires one to be connected all times one needs to access the service. Therefore faulty tolerate system is required otherwise failure of one component will make the access to cloud computing service futile.

Interoperability\Portability is one of the concerns of cloud computing. User may have all the services that are IaaS, PaaS and SaaS, the problem comes when to user requires to maneuver among the services in her operations [12]. There are no standards for interfaces of these services [16], [17]. Portability becomes another concern in that a user have services from different providers it is impossible to migrate applications between clouds or bring the system back in-house [16].

Recoveries of data in the event that there have been a data lose in whatever circumstance. The cloud computing service providers must at least assure users that their data can be recovered. This scenario can be seen when an online storage service known as The Linkup lost users' data. The users were only told that to try other service providers.

VI. Suggested Solutions

The security encompasses physical security and software security. The security is divided between the Cloud Computing Service Provider (CCSP) and the Cloud Computing End User (CCEU). The CCSP takes care of the physical security of the data centres in the countries where they are located. Make sure the laws of those countries hosting the data centres are in accordance with CCEU demands. The CCSP must protect the CCEUs from each other usually by using virtual machines. The data in transit and in storage can be encrypted. The CCEU must be able to keep the encryption key and passwords securely to themselves. A mechanism of communicating encryption key and password between the CCSP and CCEU like through e-mails.

Proprietary interfaces cause the problems of data\vendor lock-in and interoperability\portability. One solution would be to standardize the Application Programming Interfaces (APIs) in such a way that end users would be able to use different CCSPs..The general solution is to have open cloud. This will allow end users to be able to choose the CCSP of their choice at anytime depending on the circumstances. The human resource will not be expensive because an open cloud gives focus on acquisition of skills. End users can utilize different CCSPs and this will allow having backup encase disaster strike one CCSP thus allowing data recovery.

Cloud computing with fault tolerance would allow availability of cloud resources to the end users. Fig. 5 shows the proposed Open Cloud Computing System (OCCS) that allows fault tolerate operation.

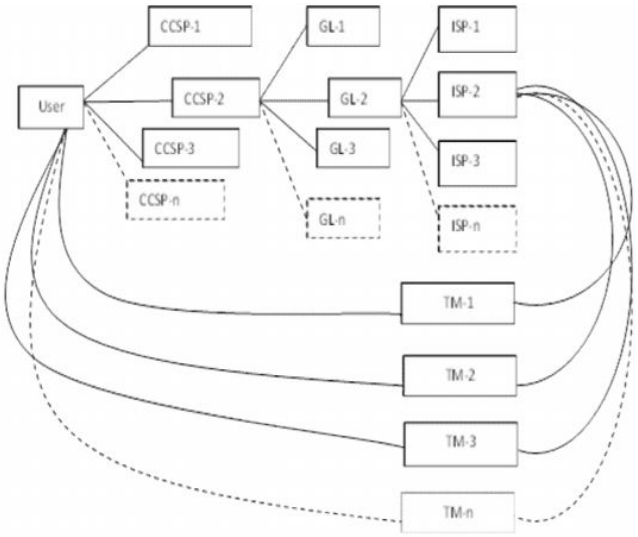

Fig. 5 Proposed Faulty Tolerate Open CC Structure

In an OCCS the user is able to use more than one CCSP encase of failure of one CCSP the user will continue to have access to CC resources. The CCSP need to have their data centres in different Geographic countries/Locations (GL) due to the fact that country laws may change or disaster strike a data centre or there is need to close the data centre users need not to feel the absence of one data centre. Users must be able to use different Internet Service Providers (ISPs) and different types of Transmission Media (TMs) to access the Internet in

order to access the cloud computing. This will allow a fault tolerant cloud computing usage.

VII. Conclusion

Cloud Computing is the new technology that delivers dynamically scalable computing resources provisioned as a service over the Internet. The promise of reduction of capital and operational expenditure on Information Technology is really enticing to businesses and individuals alike. There are concerns and challenges that need to be solved before CC can be fully accepted by business community. The technology is still in its infants, it has not been standardized to allow interoperability. There are many security issues that need to be addressed. The availability issues are also a concern since the user does not have control of the computing infrastructure and also rely on the Internet. With all these concerns that need to be addressed, there are so many businesses now offering cloud computing services. Some of them are as follows: VMware, Microsoft, Bluelock, Citrix, Joyent, Verizon/Terremark, Salesforce.com, Century Link/Savvis, Rackspace, Amazon Web Services, etc. The technology is now available on the market prompting so many researchers to come aboard to try to find solutions to the challenges of cloud computing.

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