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Understanding the Cloud: Towards a Suitable Cloud Service

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Abstract- With the rapid development of databases and data storage technology, the cloud has emerged as a significant aspect of nowadays businesses. This embraces the necessity of the distinction between the cloud services and deployment models in order to obtain a service that fits the user demands. This paper provides current and potential cloud users with the basic knowledge of the cloud services and deployment models. In addition, this paper highlights the advantages and disadvantages of this technology, while providing the cloud user with methods to benefit from cloud services in a sufficient manner, and overcome the cloud limitations and risks.

Index Terms- Cloud Computing, Infrastructure as a Service, Platform as a Service, Software as a Service

I. INTRODUCTION

With the rapid development of data storage technology, cloud computing has emerged as a significant technology trend, and a critical aspect of many businesses (Leavitt, 2009; Zhang, Cheng & Boutaba, 2010). Could computing is considered a broad term that describes a wide range of services or a stack of services (Keps, 2011). Many scholars and practitioners have attempted to define the Cloud. Klems (2008), defined the cloud as an "internet centric software" that differs from the traditional single tenant approach of software development, by being scalable, multi-tenant, multi-platform, multi-network, and global (Geelan, 2008). While Cohen (2008) described the cloud as a broad array of web-based services that allows users to obtain a wide range of capabilities on a pay-per-use basis (Geelan, 2008). Vaquero, Merino, Caceres, and Lindner (2009), suggested a definition of the cloud that focuses of the cloud features, by describing it as a large pool of usable and accessible virtualized resources such as hardware, development platforms, and services. On the other hand, Buyya,Yeo, and Venugopal (2008), proposed their definition of the cloud based on their observation of what the cloud is promising to be:

> "A cloud is a type of parallel and distributed system consisting of a collection of inter connected and virtualized computers, that are dynamically provisioned and presented as one or more unified computing resource(s) based on service-level agreements established through negotiation between the service provider and consumers."

While the cloud definitions differ in which some are business based definitions and some are technical based, there is an agreement on a definition of cloud computing provided by the National Institute of Standards and Technology (NIST):

> "Cloud computing is a model for enabling ubiquitous, 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 provider interaction. This cloud model promotes availability and is composed of five essential characteristics, three service models, and four deployment models" (Mell & Grance, 2011).

Kaplan (2008), predicted that cloud computing will be the next transformation for building virtualization enabled software (Geelan, 2008). Therefore, considering the cloud potentials in changing the future of computing, it is essential to understand the main characteristics of cloud services and deployment models in order to form accurate selection criteria that would allow users to choose the services that best fit their business needs.

The key goal of this research paper is to provide cloud current and potential users with the basic knowledge about the similarities and differences of the cloud deployment models and services, and the main benefits and downsides of the cloud. This research aims to clear the ambiguity in terms of whether or not the user should adopt this technology, and whether or not the required service is suitable for the user. This paper also describes the main characteristics of cloud computing and cloud services, while differentiating the services and deployment models of the cloud. In addition, this paper highlights the advantages and disadvantages of cloud computing in order to provide clarifications for potential users before adopting this technology. Moreover, this research emphasizes the positive aspects of cloud computing, by providing users with suggestions to overcome the limitations and downsides of cloud services in order to achieve the highest benefits of this technology.

II. CLOUD COMPUTING

1) Cloud Characteristics

The cloud has specific characteristics that makes it distinct from other similar services. While many scholars and practitioners have attempted to describe the cloud characteristics, NIST provided a list of the main characteristics that should be

available in a service to be considered a cloud. These characteristics include:

- On-demand self-service, which means that the provision of cloud resources has to be on demand whenever it is required by the users, and can be accessed through an online control panel;
- A broad network access, which means that the service has to be available for access from a wide range of devices and from different locations, whether from the internet or the private network;
- Resources are pooled, according to NIST, the provider's computing resources have to be pooled so they can serve multiple users by using a multi-tenant model according to the users demand. In general, the users have no control or knowledge over the exact location of the provided resources, however, they may be able to specify location at a higher level of abstraction (Mell & Grance, 2011);
- Rapid elasticity, which means that the service has to have the elasticity to scale larger or smaller, depending on the users/business needs;
- Measured service, which means that the service has to be measurable based on the user utilization since users are billed on a pay-per-use basis as if they are using a utility service (Keps, 2011).

2) Virtualization

Virtualization plays a significant role in enabling the cloud technology, by abstracting computer, network, and storage platforms from the underlying physical hardware (Vozmediano, Montero, & Llorente, 2012). In addition, virtualized infrastructures support server consolidation and on-demand provisioning capabilities, which results in high server utilization rates and significant cost reduction (Vozmediano et al., 2012). Virtualization environments are essential to running cloud data services (Matveev, 2010), since this technology allows multiple users of the cloud to use the same resources without having to duplicate certain aspect of the hardware (Reavis, 2012).

3) Cloud Deployment Models

Cloud deployment is the way the cloud is designed so it can provide a particular service (Naghavi, 2012). Choosing the deployment model is determined by the organizational structure and the main purpose of obtaining the cloud services. Thus, the deployment models are considered user specific (Armbrust, Fox, Griffith, Joseph, Katz, Konwinski, Lee, Patterson, Rabkin, Stoica, & Zaharia, 2009; Naghavi, 2012). In cloud computing, four main deployment models are often distinguished; these four models are: public cloud, private cloud, community cloud, and hybrid cloud. Each deployment model has its own characteristics that determine its suitability to a specific organization.

a) Public Cloud

The public cloud is based on a standardized cloud computing model, in which the resources are provisioned by a third party provider, and shared by the users. In addition, the public cloud is hosted on the premises of the cloud service provider (Mell & Grance, 2011). The users of a public cloud are billed on pay-per-use basis, which makes the public could more affordable and thus, preferable especially for small businesses. Unfortunately, since the public cloud is based on sharing resources and infrastructure with multiple organizations, it rises up security and compliance concerns for some users (Naghavi, 2012). In addition, users in public cloud lack control and visibility over the computing infrastructure (Naghavi, 2012). Examples of public cloud –also known as external cloud- include Amazon Web Services, Google App Engine, and Customer Relationship Management (CRM) solutions such as Salesforce.com.

b) Private Cloud

Since the public cloud is not suitable for the security concerned users, the private cloud is considered an alternative solution. Unlike the public cloud, the private cloud provides an infrastructure that is dedicated to a single user or an organization, and can be managed internally, externally, or by a third party. The high security level in the private cloud is attributed to the solely operating infrastructure to each user (Armbrust et al., 2009). While this deployment model is more secure, it is more expensive than the rest of the deployment models, which makes it less suitable to small and temporary business, and more suitable to large and steady business.

c) Community Cloud

Similar to the public cloud, the community cloud also provides shared resources and infrastructure. However, in the community cloud, the resources and infrastructure are shared only with organizations that have similar requirements or organization of the same group. For instance, all the government organization within a specific state can share the same infrastructure of a cloud in order to manage data related to the residents in that same state (Prasad, Choi, & Lumb, 2009). The community cloud rises up some security, policy, and compliance concerns which makes it less suitable for security concerned users.

d) Hybrid Cloud

The hybrid cloud combines different cloud deployment models. For instance, the hybrid cloud can provide a combination between the private and the public cloud, in which case an organization can host the security critical data on the private cloud, and the less security critical data on a public cloud. In addition, the cloud systems are connected in a manner that allows data be easily moved or migrated from one deployment model to another. This makes the hybrid cloud in the lead among all other cloud deployment modes (Armbrust et al., 2009; Naghavi, 2012). Although there are more than one cloud in the hybrid cloud, each cloud retains its unique entity (Naghavi, 2012), while remaining bonded together in a way that enables data and application portability (Mell & Grance, 2011). In addition, in the hybrid cloud, there is a significant need for each cloud to function in a synchronized manner in order to handle any sudden rise in computing requirements (Naghavi, 2012).

III. CLOUD DATA SERVICES

Cloud computing is a broad term that describes a wide range of services, however, it is often described as a stack of services or layers (Keps, 2011). Each layer of the cloud allows users to respond to business demands in an effective and efficient manner. These layers are: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS).

1) Software as Service (SaaS)

SaaS is a software delivery methodology that provides users with multi access as a "one-to-many model" (Keps, 2011) to software and their functions over the internet. By delivering software and application services as a web-service, SaaS eliminates the need to install and run the application on the users' computers, and thus, simplifies maintenance, support, upgrade, and data management. According to many statistics and reports, SaaS is the most rapidly growing cloud model (Keps, 2011), which indicates that SaaS is the most common model of cloud data services. In addition, when compared with other cloud data services, SaaS is considered rather developed, as other cloud services are still in the initial phase (Matveev, 2010). Mell and Grance (2011), explained he roles of SaaS as providing access to application from various locations through a thin client interface such as web browser, or through a program interface. In SaaS, the users do not have any control or management over the underlying cloud infrastructure including network service, operating system, storage, and the applicable privileges and capabilities (Mell & Grance, 2011).

Uses: SaaS is suitable for applications that mainly provide a communication line between the organization and the outside world (Keps, 2011), such as email software and video confessing. In addition, suitable SaaS fields include applications that depend on mobile access such as CRM, web analytics, and web content management (Velte, Velte, & Elsenpeter, 2009). Moreover, SaaS can be implemented to software that are to be used for a limited period of time, or for temporary projects (Keps, 2011). On the other hand, SaaS may not be a suitable solution to other situations such as: applications that require an extreme processing of data; applications where regulations do not permit data to be hosted externally; and similar applications that already fulfill the users need (Keps, 2011).

2) Platform as a Service (PaaS)

PaaS provides a platform for creating web applications over the internet, without having the complexity of buying, building, and maintaining the software and infrastructure (Choo, 2010; Keps, 2011; Leavitt, 2009). The PaaS allows software developers to write and deploy their own applications by providing them with the tools to program using a programming language that is supported by PaaS (Keps, 201; Louridas, 2010). Similar to SaaS, users of PaaS do not have control or access over the underlying infrastructure that is used to host their applications. In addition, PaaS provides a multi-tenant deployment infrastructure for applications, while providing a simple management framework and shared infrastructure for applications across organizations (Baksh, 2009). Moreover, PaaS model provides the users with the flexibility to build and deploy standard sets of shared components with a consistent software stack (Wada, Fekete, Zhao, Lee, & Liu). Furthermore, PaaS allows users to integrate, test, and modify the web services and database applications, along with providing tools to handle billing and subscription management (caps, 2011).

Uses: PaaS is suitable mostly for projects that require interaction with external parties, or where multiple developers need to work on the same project (Keps, 2011), which makes some project phases good candidates for PaaS such as application designing, development, testing, and deployment (Keps, 2011;Velte et al., 2009). In addition, PaaS is suitable for projects that require team collaboration, data integration, and storage applications (Velte et al., 2009). On the other hand, PaaS may not be a good option for applications that require high portability in terms of their hosting location (Keps, 2011). Moreover, PaaS is not suitable for applications where hardware and software customization is critical to the application performance (Keps, 2011).

3) Infrastructure as a Service (IaaS)

IaaS delivers an on-demand scalable hosted infrastructure with virtual server and storage resources, without having to buy and install the required resources and equipment (Keps, 2011). NIST defined IaaS as a cloud computing delivery model in which the consumer uses processing power, storage, load balancers, firewall, cables networking components or middleware (Mell & Grance, 2011), without having control over the cloud infrastructure beneath them (Nasr & Ouf, 2012). Naghavi (2012), described the IaaS as the provisioning of hardware related services such as storage and virtual servers, on a pay-as-you-go basis. In addition, IaaS services include simplifying and optimizing infrastructure operation, since the applications are not tied to a specific physical server, and data are not attached to a single storage device in the IaaS model (Vozmediano et al., 2012). IaaS provides several benefits from the infrastructure management perspective such as server consolidation to reduce hardware and the physical infrastructure's equipment (Vozmediano et al., 2012). By using IaaS, users are provided with a reconfigured and secured infrastructure (Matveev, 2010).

Uses: Since IaaS provides users with their required infrastructure, IaaS is beneficial for organizations that require scalability in their infrastructure and where they have unstable demand on the infrastructure, such as new business that have a possibility of expanding in the future (Keps, 2011). In addition, businesses with limited capital make good candidates for IaaS (Keps, 2011) since it provides scalability and the service is on a per-as-you-go basis (Velte et al., 2009). Moreover, IaaS is suitable for temporary businesses and business that plan on moving to a different location (Keps, 2011: Velte et al., 2009). However, users should take into their consideration the regulation of offshore IaaS providers (caps, 2011). Even though IaaS provides users with many advantages in terms of infrastructure demands, IaaS might not be the best option for

organizations that require a high level of performance and a dedicated hosted infrastructure with high capacity (Keps, 2011).

IV. ADVANTAGES VS. DISADVANTAGES

A) Cloud Data Services Advantages

There are many advantages and benefits of cloud data services. However, in order to attain these benefits, it is critical that each aspect of the cloud platform supports the key design principles and characteristics of cloud computing (Hogan, 2008). One of the key design principles is scalability (Mell & Grance, 2011), which is a critical aspect of nowadays databases and business (Harrison, 2010). The cloud provides elastic scalability for businesses (Leavitt, 2009; Wada, Fekete, Zhao, Lee, & Liu, 2011) which allows them to scale rapidly whether they are scaling larger or smaller without the associated cost and complexity (Harrison, 2010; Keps, 2011; Leavitt, 2009; Mell & Grance, 2011). In addition, the business can add more users and capabilities, without the traditional method of adding more servers to expand the capacity of usage. This creates an economic friendly pattern, especially for large databases, by minimizing the cost (Choo, 2010; Harrison, 2010) since the cloud model provides its services without the expense of installing, maintaining and upgrading an on-site infrastructure and servers. Moreover, all the resources including networking requirement and servers are shared in the cloud, which also result in minimizing costs (Hogan, 2008; Leavitt, 2009). More importantly, the cloud provides a wide range of services without the complexity of buying the hardware and software (Keps, 2011; Leavitt, 2009).

B) Cloud Data Services Disadvantages

Although the cloud provides many services that can be significantly beneficial to many organizations, there are some downsides of this technology. The most common concern in cloud computing is security (Chow, Golle, Jakobsson, Masuoka, Molina, 2009; Naghavi, 2012; Reavis, 2012), which actually varies in cloud computing based on the deployment models and the cloud service (Kandukuri, Paturi, & Rakshit, 2009; Ken, 2009). Many security issues in the cloud are attributed to the fact that all the users or the organization's information are hosted off premises and by a third-party, which means that users lack control over the infrastructure (Naghavi, 2012). There are also some privacy concerns with the cloud (Matveev, 2010), especially since the data stored in the cloud is considered a target for individuals with malicious intent (Huth & Cebula, 2011).

Chow et al. (2009), categorized the security concerns in the cloud into three categories; these categories are: traditional security, availability, and third-party data control. The traditional security includes regular computer and network threats and risks, such as attacks on the virtual machine level used by the cloud vendor; attacks on the cloud platform level, such as SQL-injections and cross-site scripting; attacks on the provider and user level such as Social Engineering; and attacks on the infrastructure level (Choo, 2010; Chow et al., 2009; Naghavi, 2012). Since cloud resources are virtualized, different users end up sharing the same infrastructure, which rises up concerns related to architecture, resource isolation, and data segregation (Lee, 2012).

The second category is availability concerns, which involves the data being available all the time (Chow et al., 2009; Lee, 2012). Cloud risks that fall in the availability category include server outage, data integrity, and natural disasters (Choo, 2010). In addition, the cloud requires constant internet connection in order to obtain access to the data stored in the cloud, which could be a concern since networks are subjected to many issues that could impact the connectivity (Jamil, & Zaki, 2011). Moreover, the cloud does not respond with low-speed internet connection (Jamil, & Zaki, 2011).

The last category is third-party concerns, which include legal and privacy implications, since cloud users lack transparency control over their data (Chow et al., 2009). In addition, the lack of clear definition of the responsibilities of users and providers may evoke conflict related to third-party concerns in the cloud (Lee, 2012). There are also issues related to software licenses which are based on the number of installations or users. Therefore, the cloud providers need to acquire more licenses than really needed at a given time (Lee, 2012).

V. DISCUSSION AND SUGGESTIONS

The cloud offers a verity of services and deployment models. Although cloud services are determined by the user's needs, it is critical to compare the user's needs with the suitability of the cloud service and deployment model. Therefore, it is essential that users understand the characteristics of the cloud and the desired service before adopting this technology. In addition, the cloud deployment models should be determined based on the criticality of the data that will be stored in the cloud, and the organization's structure. This means that users' who prefer spending lower budget on the cloud service, and have less sensitive data and low security concerns, are considered good candidates for the public cloud. In addition, the candidate users of the public cloud who prefer sharing the resources with similar organizations or business in the same field are considered good candidates for the community cloud. This distinguishes the use of public and community cloud in terms of candidacy. On the other hand, users with more sensitive data and more security concerns, and have no restrictions over their budget in terms of the services they get, are good candidates for the private cloud. Users who seek a combination of the deployment models, for instance, the security of the private cloud and the low cost of the public cloud, make good candidates for the hybrid cloud since users can use more than one deployment model. In addition, the hybrid cloud is suitable for business with high and low sensitivity of data, since they can host the sensitive data in the private could while hosting the less sensitive data in the public cloud.

Choosing the right cloud data service depends on the user's need, and more importantly, how suitable the service is to the user's need or business. This means that users who are in quest

for any of the cloud services and characteristics have to consider the suitability of the service. For instance, SaaS would not be a good option for applications that require extreme data processing (Keps, 2011). In fact, some users consider SaaS while their current applications fulfill their needs. Therefore, it is critical to layout all aspects of all data services and compare the objective of adopting cloud technology with current available service. In addition, considering the cloud limitations is considered with significant. For instance, users who are seeking the PaaS service have to consider the programming languages supported by PaaS. In addition, users who are seeking IaaS should take into their consideration that this service could have some limitations for business who need a dedicated infrastructure.

There are many advantages of cloud computing, and many benefits that make this technology desirable to many users. In addition, the cloud technology has managed to overcome the limitations of the traditional database, and provides scalable and flexible alternative without the cost, time, and effort of the traditional database. Although, the cloud technology offers a wide range of advantages, there are some downsides of this technology. The main concern for cloud computing –mainly the public cloud- is security that is mostly attributed to the lack of physical control over the data and infrastructure, and other aspects. Therefore, it is essential that potential cloud users consider both the negative and the positive sides of the cloud before adopting this technology. In addition, it is critical that users seek clarification about the Service Level Agreement (SLA), which is the document that defines the relationship between the user and the provider. Since the SLA provides clarification in terms of the user's requirement, complex issues, and many services related areas, it is critical that the users fully understand each aspect of the SLA. In addition, users are advised to consider reliable cloud providers, since outsourcing the data in the cloud means involving a third-party, which could result in many of the risks mentioned in the paper. Moreover, it is advised that current and future cloud users consider reliable security measure.

Security is a controversial subject in all data storage technologies, however, the security risks in the cloud can be mitigated and avoided by having a sufficient risk management plan and a business continuity plan to ensure that the critical functions of the business continue in case of disasters. Potential cloud users should not be overwhelmed by the security issues, since the cloud offers a verity of innovative business solutions. In addition, the security issues apply to all similar technologies, and not limited to cloud computing. The only aspect however, that makes the cloud subject to more concerns, is the ownership of data. Therefore, potential users of the cloud are advanced to clarify this ambiguity with the cloud provider before seeking this technology.

The cloud has many potentials, and relatively many advantages asides from the ones mentioned in this paper. Therefore, it is significant that users compare the deployment models, services, advantages, and disadvantages of this technology in order to have an accurate decision model for whether to adopt this service, which service is appropriate, and which deployment model is sufficient for the business needs.

I. CONCLUSION

The cloud is a rapidly developing technology that provides an alternative to the traditional databases, without the scalability limitations associated with the traditional databases. Although many scholars and practitioners have different definitions of the cloud, there is an agreement on the definition provided by NIST. In addition, NIST specified the standardized characteristics that define cloud services. Many of the cloud characteristics are attributed to the virtualization technology that allows multiple users of the cloud to use the same resources without hardware and software duplications.

The cloud has four main deployment models that allow the cloud to provide its services; these models include public, private, community, and hybrid cloud. The cloud deployment models vary in terms of cost and security level. For instance, the public and community cloud carry some security concerns due to the shared infrastructure. Thus, they are more suitable for users with less sensitive data. In addition, the shared infrastructure means that users are sharing the resources, and thus, have lower cost. On the other hand, the private cloud is more secured due to the dedicated infrastructure to each user. Thus, it is more suitable for users with sensitive data or users with high security concerns. Although the private cloud seems more preferable due to the high security as apposed the community and public cloud, the dedicated infrastructure makes it more expensive than other deployment models. The variety of security and cost, particularly among the public and the private cloud, makes the hybrid cloud more desirable since it provides a combination of two or more cloud services. This allows users to host the sensitive data in the private cloud and the remaining data in the public cloud. Thus, result in achieving the required security level and cots saving since the cloud users are billed on a per-per-use basis.

The cloud provides a wide range of services that include SaaS, PaaS, and IaaS. Cloud services vary in terms of uses and suitability. It is critical that users understand the characteristics of the desired cloud service, and its suitable uses in order to decide whether to adopt the service. More importantly, it is critical that users understand the advantages and disadvantages of the cloud services in order to achieve the height benefits, yet mitigate or avoid the possible risks. This includes choosing the appropriate cloud service and deployment model in order to benefit the business, while choosing a reliable cloud service provider and considering security measures and a risk management plan, since security is the most common concern in the cloud. In addition, it is critical to review the SLA while choosing the cloud provider, to avoid any ambiguity in terms of the issues and users' requirements.

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