Factors for cloud computing technology adoption: An exploration of scaling strategies

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ABSTRACT

Cloud computing is a viable alternative for many organizations. Cloud computing provides varying levels of service such as IaaS, PaaS, SaaS, and DaaS. This is attractive to organizations that require an IT infrastructure but do not wish to build and manage such infrastructure. In this research article, the varying levels of cloud service will be analyzed. A suggested technology adoption model for cloud computing services will be provided. This model may be used by organizations to fit their cloud computing service selection to their business requirements.

Keywords: cloud computing, technology, infrastructure, technology adoption, TAM.

INTRODUCTION

In recent years, the widespread generation, transmission and storage of ever-increasing types and volumes of data is creating a massive load on networking and storage infrastructures. Cloud computing is emerging as the latest distributed computing paradigm, which provides inexpensive, reliable, redundant and scalable resources on demand to organizations implementing this technology. Organizations are adopting one or several cloud services models to cost-effectively enhance their efficiency.

Aside from increased demand for cloud services on the part of many organizations, cloud computing is emerging as a cultural iconic expression. Ben Pring, from Gartner, is quoted as saying, "It's becoming the phrase du jour" (Knorr & Gruman, 2008, p. 1). Cloud computing is reshaping the data center and the organizational IT domain. According to Siegele's 2008 article in The Economist, "cloud computing will have huge impacts on the IT industry, and profoundly change the way people use computers" (as cited in Hu et.al.,2011, p. 25).

According to Avram (2014). "cloud computing is an attractive alternative to business owners and IT operations as it eliminates the requirement for IT planners to predict provisioning requirements" (p. 530). Adopting cloud computing allows enterprises to start with the minimum amount of technology resources required and then increase these resources only when the service demand accelerates. Although cloud computing offers huge opportunities to the IT industry, the development of cloud computing technology is currently in its infancy and has many critical issues to be addressed.

This new and innovative technology known as cloud computing is allowing companies to change the way they deliver and manage IT (Lasica, 2009). From the purchase of powerful yet inexpensive IT (Hackett, 2008) to the ultimate delivery to customers, cloud options have impacted all areas of providing IT service. However, these options have a price to pay with regard to supporting such a complex infrastructure. As Marston, Li, Subyajyoti, and Ghalasasi (2011) point out the paradox of cloud computing:

> "On one hand, computers have been continued to become exponentially more powerful and the per-unit cost of computing continues to fall rapidly, so much so that computing power is now considered to be largely a commodity. On the other hand, as computing becomes more ubiquitous within the organization, the increasing complexity of managing the whole infrastructure of disparate information architectures and distributed data and software has made computing more expensive than ever before to an organization" (p. 1).

LITERATURE REVIEW

In a general sense, cloud computing is the combination of two areas of importance for information technology. The first area, IT efficiency, is where there is a precise utilization of modern computational technologies through highly scalable hardware and software resources. The second area is providing organizations competitive advantage through agility. This is accomplished through rapid IT delivery, mobility, and delivering real-time, computationally demanding service in a seamless, responsive manner (Kim, 2009).

The exact definition of what constitutes cloud computing is subject to some academic debate. However, Buyya, Yeo, Venugopal, Broberg, and Brandic (2009) have defined it as follows: "The Cloud is a parallel and distributed computing system consisting of a collection of

inter-connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements (SLA) established through negotiation between the service provider and consumers" (p. 601). In addition, Vaquero, Rodero-Merino, Caceres, and Lindner (2008) has explained cloud computing and clouds as:

> "a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services). These resources can be dynamically reconfigured to adjust to a variable load (scale), allowing also for an optimum resource utilization. This pool of resources is typically exploited by a pay-per-use model in which guarantees are offered by the Infrastructure Provider by means of customized Service Level Agreements" (p. 51).

McKinsey and Co. report has recently claimed that "Clouds are hardware-based services offering compute, network, and storage capacity where: Hardware management is highly abstracted from the buyer, buyers incur infrastructure costs as variable OPEX, and infrastructure capacity is highly elastic" (Lublinsky, 2009, para. 4).

The ultimate intention is to make the cloud computing convenient for the customers to run their everyday IT infrastructure. Cloud computing is a result of the combination of several other technologies that already existed. As Avram (2014) explains, "these technologies have different maturity rates in different contexts and were not designed as a coherent whole; however, they have come together" (p. 531) in the making of cloud computing. Avram (2014) goes on to explain that the evolution of many technologies such as faster and less expensive multi-core processors, large, scalable disk arrays, and increased network bandwidth have made cloud computing an attractive opportunity for many organizations.

Five Essential Characteristics of Cloud Computing

Cloud computing, by most modern definitions, provides five essential characteristics. According to NIST (Badger et al., 2011), these five essential characteristics can be classified as:

On-demand self-service. This refers to the service that is provided by the cloud computing vendors and allows consumers to "access different services, computing capabilities, storage services, software services etc. as needed automatically" (p. 15) without requiring human interaction and can acquire these resources almost instantly.

Broad network access. IT is hosted in a private cloud network, which is generally operated in a company's firewall and are accessible from a wide range of locations that offer online access as well as number of devices, such as smartphones, tablets, PCs and Macs.

Resource pooling. The cloud service providers use resource pooling to pool computing resources and share computing capabilities. This leads to increased resource utilization rates. The resources demanded by users can range from "processing, software, storage, virtual machines and network bandwidth" (p. 15). The resources are aggregated independently regardless of the resource location. However, consumers might be able to specify the exact location at a higher level of abstraction.

Rapid elasticity. The ability to provide scalable services is referred to as rapid elasticity. In other words, rapid elasticity is a cloud computing term for scalable provisioning. This is one of the hallmarks of cloud computing. Rapid elasticity allows the user to request additional

resources in the cloud automatically without regard to time or resource amount. The requested resource allocation does not require involvement on the part of the cloud service provider . The request is fulfilled automatically. To ensure a high-quality delivery service in a secure way, this flexibility allows the consumers to quickly scale up and down according to their needs.

Measured service. Aspects of the cloud services are controlled and monitored by the service provider here. A metering capability is set to charge users based upon access control, billing rates, resource optimization, capacity planning and so on. The users can use the different quality of services according to how much they pay. This ensures resource optimization at "different levels of abstraction appropriate to the type of service" (p. 15) such as SaaS, PaaS and IaaS).

Service Models

In procuring cloud-based services, the following service models are most commonly associated with cloud computing:

Software as a Service (SaaS)- This is one of the most popular forms of cloud computing and is defined as a software distribution model in which cloud consumers release their applications on a hosting environment, which is available through networks from various clients (e.g. web browser, PDA, etc.) by application users. As Dillion, Wu, and Chang (2010) explain "the consumers do not have any interaction with the Cloud infrastructure" (p. 28). Instead of installing and maintaining software, the consumers simply access it through Internet. The provider manages all aspects of the software including security, backups and performance of the software. Examples of SaaS include Microsoft Office 365, Box, Amazon Web Services, Google Mail, and Google Docs.

Platform as a Service (PaaS). PaaS is an established model which frees users from installing on-premise hardware and software to run or develop a new application. PaaS enhances application development by adding operating systems, middleware (e.g., database) and other runtimes in the cloud environment. It is a "development platform that hosts both completed and in-progress cloud applications" (Dillion, Wu, & Chang, 2010, p. 28) whereas SaaS only hosts the completed cloud applications. This requires PaaS, in addition to supporting the application hosting environment, to possess a development infrastructure including a programming environment, tools, configuration management, and other platform tools. An example of PaaS is Google's AppEngine.

Infrastructure as a Service (IaaS). This form of cloud computing involves cloud consumers to directly use virtualized resources over the internet. IT infrastructure resources such as CPUs, disk space, and networking bandwidth are owned and hosted by a service-provider and provided to customers on-demand in the IaaS cloud. Customers may partition and activate a VM independently from other machine platforms and independent from the infrastructure. IaaS allows business organizations to use web-based operating systems, storage and applications without having the complication of manage, support and purchase the underlying cloud infrastructure. Common examples of IaaS include Google Compute engine(GCE), Rackspace.com, and Microsoft Azure.

Data storage as a Service (DaaS). This cloud computing strategy is enabled by a service-provider that enables data access on demand to the consumer in a well-timed, protected and affordable manner regardless of their organizational and geographic location. There is off-set of costs by managing complex data sets by in-house IT maintenance. Consumers are allowed to

(but not required) pay for only the storage they use rather than the site license for the entire database. Examples of most common business applications powered by DaaS technology includes Customer Resource Management (CRM) and Enterprise Resource Planning (ERP) applications.

Key advantages of cloud computing

Users of cloud computing can benefit from several key advantages. These include lower costs, instant hardware availability, infrastructure scalability, and increased services delivery.

Cloud computing lowers the cost of computer intensive analytics making it easier for smaller firms to compete with larger firms. Before the option of cloud computing existed, smaller firms would have to invest in expensive computing equipment to run analytical tests that lasted only a short time. Now, with cloud computing options available, smaller firms can run these tests and not have to absorb the upfront investment of computer equipment and infrastructure expenditures. This lowered entry cost and ease of access to more powerful computing equipment will give access to areas of the world that have been deprived of this technology for various reasons.

When a firm chooses to use cloud computing they can have instant access to hardware resources. This technology allows IT users to utilize computational infrastructure beyond the walls of their actual office. Cloud computing gives instant access to all users with Internet connectivity and access to the firm's cloud. When firms elect to use cloud computing for their hardware needs it allows them to be more adaptive and more mobile than if they had invested in the physical hardware.

Another advantage that comes along with cloud computing is scalability. Using the cloud allows firms to easily scale their IT needs up and down as required. This on-demand scaling lowers IT barriers for large and small firms alike. Avram (2014), found that the use of cloud computing can lower IT barriers for many companies. The ease of scalability is gaining popularity with many firms. The rise in popularity is due in part to not having to directly interact with the providers of the cloud, but still being able to scale the cloud almost instantly.

Cloud computing has also allowed applications to deliver services that they were not able to before. Marston et al. (2011) mention these services that include mobile interactive applications, parallel batch processing, business analytics, and extensions of compute-intensive desktop applications. Cloud computing allows companies to take advantage of these services and allows the users of their applications to utilize the services from anywhere network connectivity is available. Cloud computing has simultaneously made advancements in technology and given this advancement available to more users than before, all the while making it easier and cheaper to use.

TECHNOLOGY ADOPTION FACTORS

Selecting a specific cloud computing technology depends upon the technology requirements of the organization. Many companies will adopt multiple cloud technologies as dictated by their technology needs and business strategies. For instance, an organization can adopt SaaS applications such as Cisco's Webex coupled with PaaS (e.g., Azure) as a platform to deliver its own applications to customers. Additionally, the company could use an IaaS strategy such as Rackspace.com to expand its own data center and CPU availability.

Table 1 (Appendix) specifies the cloud computing technology adoption model. The model identifies strengths and weaknesses of IaaS, PaaS, SaaS, and DaaS. Additionally, the proposed model offers technology adoption assistance in selecting a specific cloud technology compared to other offerings in the cloud services market.

Deployment models

According to the research literature, four kinds of cloud deployment models have been defined and will be discussed in this research article. These models include private cloud, the community cloud, the public cloud, and the hybrid cloud. In addition, the more recent addition (the Virtual Private Cloud) is presented as well.

Private cloud. This model operates within the individual organization that is using cloud. IT services are provisioned over private IT infrastructure for the dedicated use of that particular organization. An organization may have several reasons to set up a private cloud. One example is that firms want to be able to maximize their existing resources. A second example is private clouds are better secured and offer more privacy to users. A third reason for choosing this model is transferring data to a private cloud can be more cost beneficial than transferring data to a public cloud constantly (Fox et al., 2009). A forth reason they choose this model is legally a company or firm could be required to maintain full control of their information or activities. Finally, some may choose this model due to the want or need to build a private cloud. This is often seen in research, teaching, or other academic settings.

Community cloud. In this cloud framework, several organizations jointly create and share the same cloud infrastructure. The organizations' missions may vary but they do share similar security, privacy, performance and compliance requirements. Community clouds are often structured for business and organizations working jointly which results in a "degree of economic scalability and democratic equilibrium" (Dillion, Wu, Chang, 2010, p. 28). Community clouds can exist at the participants' data centers or hosted by third-party service providers.

Public cloud. This architecture is arguably the most well-known Cloud architecture to most organizations. This model is offered by third-party providers over the public Internet and used by public customers. The cloud providers have their own resources, such as virtual machines (VMs), applications or storage; which are available to the general consumers over the Internet. Some examples of popular public cloud services include Amazon EC2, S3, Google AppEngine, and Salesforce.com.

Hybrid cloud. Chang (2015) defines this model as a "a combination of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load-balancing between clouds)" (p. 134). Companies adopt the hybrid model for efficiency and to optimize their resources through public cloud services for all non-sensitive operations, while their private cloud is used only when it is needed. In this deployment model, it is a requirement that all platforms and their respective applications be seamlessly integrated.

Virtual Private Cloud. Interestingly, a new type of deployment model called- Virtual Private Cloud (VPC) has been introduced by Amazon Web Services (AWS). This cloud deployment model establishes a secure and seamless bridge between an organization's existing IT infrastructure and the Amazon public cloud. It is a private cloud located inside a public

cloud that enables the users to experience the benefits of a virtualized network while using public cloud resources.

A VPC isolates all consumers' data from any other data traffic, both in transit and in the cloud provider's network. This data isolation methodology is important to create a more secure environment. The most common billing approach for this type of cloud deployment model is Pay-per-use.

Selection Factors

Al-Jabri et al. (2018) credit seven factors to the choosing of different cloud computing service models. These factors include: cost, adaptability, available IT skills, urgency, security of data, privacy of data, and service reliability.

Cost. The cost of a cloud computing service model is the sum of the amount charged by the service model and the cost incurred to maintain and support the model. Since one of the main advantages of going to the cloud is cutting cost, analyzing how much each model will cost is an important factor for enterprises.

Adaptability. Adaptability is how easy it is to change the cloud to the needs of the user. Adaptability or scalability is another advantage of moving to cloud computing. In cloud computing, users can easily change the scale of their operation to what they think they need. Having the adaptability that enterprises desire and require is an important weigthing factor in which service model they choose.

Available IT Skills. Available IT skills are the skills the enterprise has available to them from their own IT perspective. The size and experience of an enterprise's IT department can influence what they are looking for in their cloud service model. An enterprise with a large and skilled IT department may not need all the services that an enterprise with a smaller not as skilled IT department requires.

Urgency. Urgency refers to how quickly the service model can be implemented for the enterprise. The quicker the service is needed, the more willing the enterprise will be to select the quickest to launch service model. The firm can then quickly launch the aspect of their business that will be hosted by the cloud provider.

Security of Data. Security of data is how the data of the enterprise is kept by the cloud and how easily accessible it is to the enterprise yet secure from compromise and attack. The cloud is supposed to offer its users the ability to access their data from a variety of places in both a fast and secure fashion. Enterprises want to make sure the model and provider they choose will allow them the most versatile access to their data as well as provide protection from intrusion and unwanted access.

Privacy of Data. As mentioned above, users of the cloud want to be able to access their data from different locations. In addition to being able to access it easily they want their data to be secure from unauthorized access by third parties. Privacy in the service model is large concern for many enterprises. Public clouds tend to be less secure when compared to private or hybrid clouds.

Service Reliability. Service reliability is another important factor for determining which cloud provider and service an enterprise chooses. Users of cloud computing want to be able to access their data whenever they desire. Downtime and interruption of their connection to their data will tend to drive off users to other service providers. A cloud vendor that can provide

assurance that a customer will not incur downtime or interruption will be used more often than one that cannot guarantee this to customers.

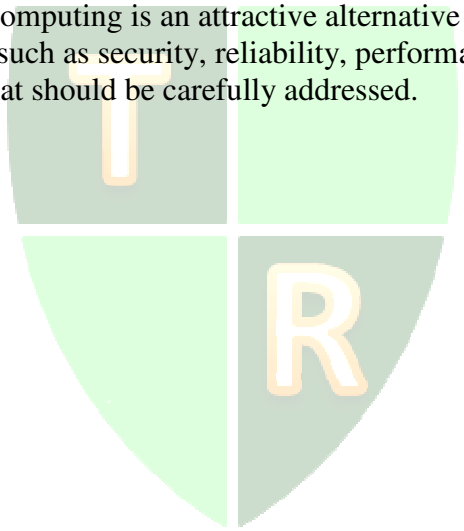
CONCLUSION

Cloud computing has been introduced recently in business sectors. Cloud computing services are providing users with direct, collaborative, computational resources. These virtualized resources are usually at a cost savings to the cloud users. The Cloud provides on-demand, scalable, resources for the customer which could reshape the competitive landscape for smaller firms.

It is thought that in near future almost all businesses will be using cloud computing as an integral component of their businesses. The Cloud will bring a massive change in the landscape of the IT industry and those that adopt cloud computing services. The Cloud brings computational power to those entities that could not otherwise obtain the economies of scale required for large-scale computing and IT services.

There are several advantages of cloud computing which includes low cost of entry, increased technology efficiency and availability, lower technology staffing models, and reduced operation costs. The pricing model of on-demand technology and meeting technology costs as they occur is appealing to many organizations.

Any particular cloud computing model is selected based on an organization's requirements. Although cloud computing is an attractive alternative to many firms, there still exists many challenging issues such as security, reliability, performance, interoperability, scalability, and virtualization that should be carefully addressed.



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APPENDIX

Table 1

Cloud computing adoption model (Adopted from Harvey, 2018)

Types of Cloud Computing	Strengths	Weaknesses	Best for
IaaS	·Vendor manages physical infrastructure ·Organizations can mirror their in-house infrastructure in the cloud ·Easy scaling ·Flexible and highly customizable ·Cost varies with consumption of resources ·Low costs ·Relatively easy integration with other system ·Relatively low potential for vendor lock-in	·Customer manages applications, data, OS, etc. ·Costs may be unpredictable ·Requires skilled personnel	·Organizations migrating existing workloads to the cloud ·Hybrid cloud environments ·Large enterprises with an existing IT staff ·Organizations with existing software licenses that can be moved to the cloud
PaaS	·Vendor manages physical infrastructure, plus the operating system, runtime, middleware and possibly other development tooling ·Developers can focus on writing code rather than managing infrastructure ·Streamlines and speeds application development and testing ·Easy creation of dev and test environments that are identical to production environments ·Easy scaling ·Cost varies with consumption of resources	·Costs may be unpredictable ·Customer has less control than with IaaS ·Requires more management and configuration than SaaS ·Requires skilled personnel ·Some potential for vendor lock-in	·Developers creating new cloud-native applications ·DevOps teams ·Large organizations with custom in-house applications
SaaS	·Vendor manages all infrastructure and software ·No need to download, install or upgrade software on PCs and other devices ·Costs are predictable ·Fast, easy setup ·Anyone can use it	·Usually fewer customization options ·May be more difficult to access and protect data stored in SaaS applications ·Customer may be charged subscription fees for users who access the service rarely or never ·No control over software or infrastructure ·Integration with other software may be difficult ·Vendor may have access to customer data ·High potential for vendor lock-in	·Small organizations with minimal IT staff ·Applications that require mobile access ·Replacing a particular type of business software
DaaS	·Low cost compared to other options · Lessens the need for physical storage, backups, redundancy · Allows data to be stored and accessed remotely	· Security/privacy questions · Vulnerable to vendors technology problems · Users can be reluctant to give data to outside provider	· Cheaply and efficiently backing up data · Companies that do not want to invest in physical storage · Storing data remotely, but can also be easily accessed