A Review on Cloud Computing Adoption: An Exploratory Analysis

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Abstract

The world has been witnessed with many technological revolutions. One of them is the computing technologies. There have been many revolutions such as mainframe computers, super computers, web technologies, Internet, grid computing, utility computing, etc. Cloud computing is another evolutions in the field of computing and it has been evolved from the earlier computing technologies by the integration of some of them and removing the obstacles encountered in them as a new technology. Amazon, Google, Microsoft, Salesforce.com, are some of the organizations who provide this technology to organizations and personal users.

Cloud computing has attracted many people, researchers, and professionals towards it Many people have done researches on it and many articles and conference papers on varying aspects of cloud computing has been published. The purpose of this is paper is to review those research articles and conference papers to compile the concepts and various aspects of it in order to enlighten the concept more understandable to all varieties of people since it has been a new concept and many people are not aware of it by using exploratory analysis as methodology. The paper focuses on the different definitions of cloud computing, characteristics, underlying technologies, different cloud services, cloud deployment model, advantages and disadvantages of cloud computing, cloud computing implementation issues, adoption status of cloud computing, and future research areas.

Keywords: cloud computing, technology adoption,

Introduction

Overview on Cloud Computing

Cloud computing is an emerging Internet-based technology through which information is stored in servers and provided as an on-demand service to clients. It helps organizations of all kind to be more efficient in their ICT deployment in their organization and promote growth, competition, and business creation. Cloud computing provides a shared pool of computing resources that can be provided and stoppedas and when the users need to satisfy a wide and constantly increasing range of information processing needs(Alshwaier, Youssef and Emam, 2012).Yahoo email, Gmail, Google docs etc are some of the simple example of cloud computing (John Rhoton, 2011).

According to Garner's study, enterprise's spending on cloud computing is growing faster than overall IT spending and predicts that cloud computing technology will grow by over 100 percent to become a USD$127 billion industry by 2016 (Prweb, 2012). Further, a joint IBV/EIU cloud-enabled business model survey also revealed that 62 percent of CIOs consider cloud computing as the leading and important priority for IT (Berman, 2011). Presently US takes the lead and Europe lags behind due to regulations on security, integration, performance, and reliability concerns (Berman et al., 2011). Based on a survey in 2010 (DigitalOne, 2010), 59 percent of Asian companies were either using or planning cloud computing.

In this computing model, personal users and organizational users would be able to access all of their documents and data from any device (the home or work personal computer [PC], the mobile phone, or an Internet point, among others) and anywhere and cloud vendors would be able to rent computing power (both hardware and software in their latest versions) and storage on demand for a fee. Cloud computing could be used in two ways to meet the information technology requirements. One is for IT efficiency, whereby the power of modern computers is utilized more efficiently through highly scalable hardware and software resources and the second is for business agility, whereby IT can be used as a competitive tool through rapid deployment, parallel batch processing, use of compute-intensive business analytics and mobile interactive applications that respond in real time to user requirements (Sean Marston, 2011).

Objectives

This research paper sought to achieve the following objectives. First, to identify the various concepts related with cloud computing, to identify the different stakeholders with the cloud computing services, to celebrate the underlying technologies behind the cloud, identify the issues, to focus on the adoption status of cloud computing , and finally to suggest future research areas in cloud computing.

Methodology

Exploratory analysis was used in this paper since it is a new concept and reviews the exiting literatures. Some of the more popular methods of exploratory research include literature searches, depth interviews, focus groups, and case analyses. Literature search is one of the quickest and least costly ways to discover hypotheses is to conduct research. There is an incredible amount of information available in libraries, through online sources, in commercial data bases, and so on. The literature search for this research involved popular press (newspapers, magazines, etc.), trade literature, academic literature, or published statistics from research firms till today on the concept.

Definitions of cloud computing

As with all the concept, cloud computing is also defined in various ways and various point of view. There are many definitions of cloud computing and some of the definitions which different researchers and professional bodies have been provided in this section in order to understand the concepts related with cloud computing in the subsequent sections. The most comprehensive definition available is by Brendl (2010) who defined cloud computing as "collections of IT resources (servers, databases, and applications) which are available on an on-demand basis, provided by a service company, available through the internet, and provide resource pooling among multiple users." (Bisong and Syed Rahma, 2011).

The Gartner consulting propose a definition as follows "A style of computing where scalable and elastic IT-related capabilities are provided as-a-service using Internet technologies to multiple external customers" (Plummer et al., 2009). The National Institute of Standards and Technology (NIST) defines cloud computing as " a model for enabling convenient, ondemand network access to a shared pool of configurable computing resources (e.g., network, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

Borenstein and Blake (2011) sees it as "…the use of fast, high-bandwidth Internet connections to deploy services that are centrally maintained, often by third parties, and thus minimize the cost and difficulty of IT administration and support for the organizations that consume those services." Buyya et al (2008) define cloud as "a type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified resources based on service-level agreements established through negotiation between the service provider and consumers."

Foley (2008) provides this explanation: "Cloud computing is on-demand access to virtualized IT resources that are housed outside of your own data center, shared by others, simple to use, paid for via subscription, and accessed over the Web." In another article, cloud computing is defined as follows: "It is an information technology service model where computing services (both hardware and software) are delivered on-demand independent of device and location. (Sean Marston, 2011).

Evolution of cloud computing

The underlying concept of this computing style dates back to the 1960's, when John McCarthy, the computer and cognitive scientist, first envisioned the possibility that "someday computation may be organized as a public utility" (Mohamed, 2009). Since then, cloud computing has developed into several different lines, the most recent of which is Web 2.0. The shift of computing trend toward cloud computing started in the late 1980s with the concept of grid computing when, for the first time, a large number of systems were applied to a single problem, usually scientific in nature and requiring exceptionally high levels of parallel computation. In 1999, a company named Salesforce.com pioneered the concept of delivering enterprise applications using the internet (Mohamed, 2009). The company introduced Software-as-a-Service (SaaS) to companies by applying many of the technologies developed by leading companies such as Google and Yahoo! to business applications. This allowed companies to use the software on as-needed basis rather than purchasing it outright. Microsoft extended SaaS with the development of its Web Services in the early 2000's by allowing the means for SaaS software to connect to other software applications using the World Wide Web (Nafisa, 2009).

The first mover in the field of cloud computing has been Amazon, which has provided access to half a million developers by way of Amazon Web Services (initially developed for internal purposes).Elastic Cloud Computing (Amazon EC2) is one of the cloud services of Amazon. Google is also investing huge amounts of funds in data centers. Already today Google provides word processing, presentation and spreadsheet applications online as Google Docs and Gmail, while software and data are stored on the servers. Google App Engine allows software developers to write applications that can be run for free or fee on Google's servers. Even Google's search engine or mapping service can offer cloud application services: for instance, when Google Maps was launched, programmers easily found out how to combine the maps with other information to provide new services. Microsoft started later but has made high investments in the creation of new data centers. In January 2010, the leading software company launched a cloud platform called Windows Azure (introduced in a beta version in 2008).

Moreover, Windows Azure provides a browser-accessible portal for customers, who can create a hosting account to run applications or a storage account to store data in the cloud. Another important player is Salesforce.com with its Force.com products. Also Oracle has introduced a cloud-based version of its database program and is merging with Sun Microsystems to prepare further expansion in the field. Finally, Yahoo! is developing server farms as well.

Characteristics of cloud computing

The essential characteristics are:

Table 1: Cloud computing characteristics

Characteristic	Description
On-demand self service	IT is used as service and is readily available on demand without requiring manual intervention.
Broad network access	The service is made available via a network independently of the user end device. The network connection must be of sufficiently high performance and available for that particular service.
Resource pooling	The provider makes the necessary resources available to multiple consumers using technologies such as virtualization and multi tenancy.
Rapid elasticity	The resources necessary can be provisioned rapidly and released without manual intervention when no longer needed.
Measured Service	A service consumed must be measurable in terms of the resources used. In this way, consumption-based billing becomes possible. Also known as "pay as you go" or "pay-per-use."

Source: Based on "The NIST Definition of Cloud Computing" by P. Mell and T. Grance, Special Publication 800-145 (National Institute of Standards and Technology, Gaithersburg, MD, Sept. 2011). In some other studies, the Cloud computing has the following basic characteristics (NIST, 2011, IBM Global Technology Services, 2011, Nanda1 and Mishra, 2010).

Elasticity and scalability: services should be available all the time 24*7, and be designed to provide high scale service during peak times and also during lighter zones. It should be scalable when additional users are added or when requirements change and ability to scale is achieved by providing elasticity.

Self-service provisioning: Customers to avail themselves of Cloud services; what the customer needs to do is simply he or she has to request the type of service he requires. The request can be computing, storage, software process or some other resources from the service provider.

Application Programming Interfaces (APIs): Standardized APIs are needed for Cloud services. The instruction regarding communication between 2 applications or data sources is provided by these interfaces. An easily link for the customer with a Cloud service is done by a standardized interface such that customized programming is not needed, for example a customer relationship management system with a financial management system.

Performance monitoring and measuring: A service management environment must be included by the Cloud service provider which is an integrated approach for managing physical environments and IT systems. Service management has to be monitored to optimize the services. Many customers use their own monitoring tools for determining whether the service level requirements are being met.

Security

Many people are scared about their data privacy. Many customers need to trust that the Cloud services are safe. To give critical data or application infrastructure to a Cloud-based service provider requires an assurance that the information has not been accidentally retrieved by another company (or hacked). The security concept should be dealt with as a serious issue in Cloud Computing as critical data resides over Cloud. The user trust can be built up if strategies regarding network behavior, user behavior, processing behavior are made (Li-qin and L Chuang, 2010).

Core Concepts and Technologies of cloud computing

Cloud computing is an emerging new computing paradigm for delivering computing services. This computing approach relies on a number of existing technologies, e.g., the Internet, virtualization, grid computing, Web services, etc (Nabil Sultan, 2010).Further, it is composed several Strata of Services. These include services like Infrastructure as a Service, Storage as a Service, Platform as a Service and Software as a Service. Different Cloud Providers have developed various access models to these services. The access to these Services are based on standard Internet Protocols like HTTP, SOAP, REST, XML and the infrastructure is based on widely used technologies including Virtualization, hosting. Cloud Computing is the maturation and coming together of several prior computing concepts like Grid Computing, ASP, Server Hosting, Utility Computing and virtualization. Another related concept is the multi tenancy, whereby a single instance of an application software serves multiple clients. This allows better utilization of a system's resources (in terms of memory and processing overhead), the requirements of which could otherwise be considerable if the software instance had to be duplicated for each individual client.

Advantage sand Disadvantages of cloud computing

As with other technology, cloud computing also provides many advantages and disadvantages. Cloud computing with its different deployment and delivery models offers a number of benefits to businesses (Voona and Venkantaratna, 2009, Buyya et al., 2008, Miller, 2008, Catteddu and Hogben, 2009, Andrei, 2009). These benefits are such as: economies of scale resulting in low-costs of IT infrastructure, low maintenance costs and low IT administration costs. Other benefits are, improved of performance as a result of having access to dynamic and scalable computing, memory and storage capabilities based on demand. Cloud computing also offers easier data monitoring, quick incident response, and low costs to undertake security measures. Easier group collaboration, universal access to computing resources and the removal for the need for specific devices or hardware in-house are also benefits that can be accrued from cloud computing.

It dramatically lowers the cost of entry for smaller firms trying to benefit from compute-intensive business analytics that were till then available only to the largest of corporations and it can provide an almost immediate access to hardware resources, with no upfront capital investments for users, leading to a faster time to market in many businesses. Cloud computing also makes possible new classes of applications and delivers services that were not possible before. Examples include (a) mobile interactive applications that are location-, environment and context-aware and that respond in real time to information (e.g. humidity and stress sensors within a shipping container) or even from independent information services (e.g. worldwide weather data); (b) parallel batch processing, that allows users to take advantage of huge amounts of processing power to analyze terabytes of data for relatively small periods of time, while programming abstractions like Google's MapReduce or its open-source counterpart Hadoopmakes the complex process of parallel execution of an application over hundreds of servers transparent to programmers; (c) business analytics that can use the vast amount of computer resources to understand customers, buying habits, supply chains and so on from voluminous amounts of data; and (d) extensions of compute-intensive desktop applications that can offload the data crunching to the cloud leaving only the rendering of the processed data at the frontend, with the availability of network bandwidth reducing the latency involved.(Sean Marston et al. 2011)

However, cloud computing has a number of disadvantages such as: requiring a constant internet connection, can be slow in case of slow internet connections, limited features offering, security might not meet the organization standards, danger of loss of business in case of data loss or cloud vendor filing for bankruptcy (Miller, 2008, Jeffrey and NeideckerLutz, 2009, Ristenpart et al., 2009).Moreover, many security and privacy incidents are also observed in today's Cloud Computing systems. Afew latest cloud security concerns such as; In March 2011 a prolonged period of interruption to Amazon's Elastic Block Storage (part of the AWS offering) caused a large number of websites to go suddenly, and painfully, dark, cloud storage provider Dropbox suffered from an administrative error, Google Docs found a flaw that inadvertently shares users' docs in March 2009.

One of the top security concerns of enterprises are the physical location of the data that are being stored in the cloud especially if they are located in another country because the laws of the host country of the equipment apply to the data on the machines (Smith, 2009) and that could be a big issue if the host country does not have adequate laws to protect sensitive data or if the host nation becomes hostile or when the government of the hosting nation changes and become unfriendly (Bisong and Rahman,2011). Cloud computing faces just as much security threats that are currently found in the existing computing platforms, networks, intranets, internets in enterprises. These threats, risk vulnerabilities come in various forms. The Cloud Security Alliance (Cloud Computing Alliance, 2010) did a research on the threats facing cloud computing and it identified the Following seven major threats; abuse and Nefarious Use of Cloud Computing, insecure application programming Interfaces, malicious insiders, shared technology vulnerabilities, data loss/leakage, account, service &traffic hijacking, and unknown risk profile. Information stored with a third party (including a cloud computing provider) may have fewer or weaker privacy protections than information in the possession of the creator of the information. IT managers are likely to be wary of surrendering control of their resources to outside providers who can change the underlying technology without customers consent (AlSudiariand Vasista, 2012)

Cloud computing delivery and deployment models

Cloud computing has three delivery or service models and four deployment models that are popular (Vouk, 2008, CSA, 2009, Mell and Grance, 2009a, Mell and Grance, 2009b). The cloud computing promotes X as a Service (XaaS) view, where X can

be any computing function provided via the cloud computing, such as Software (SaaS), Platform (PaaS), and Infrastructure (IaaS).The following service or delivery models are available with cloud offering. Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS) and Infrastructure as-a-Service (IaaS). In SaaS the organization outsources everything by renting remotely accessed services via the Internet. The client uses the provider's applications or software through different client devices via a thin client interface such as a web browser (Mell and Grance, 2009a). Examples of SaaS providers are salesforce.com, Netsuite and Oracle CRM on Demand. For PaaS, the service provider rents dedicated resources to a client. In this offering the client has the ability to deploy on the cloud his/her own created applications or software using programming languages and tools supported by the provider (Mell and Grance, 2009a). Examples of Paas services are Google Application Engine, force.com. The Infrastructure-as-a-Service (IaaS) is another model and dedicated resources are offered to a single tenant or client and do not allow sharing of dedicated resources to unknown third parties. The model provides the customer with ability to deploy applications on the cloud infrastructure. The applications may include operating systems and other applications. However, the customer does not have control over the infrastructure but may control the deployed applications and operating systems, storage and selected network components (Mell and Grance, 2009a). Figure 1 shows the cloud taxonomy showing different types of offerings in the different delivery models.

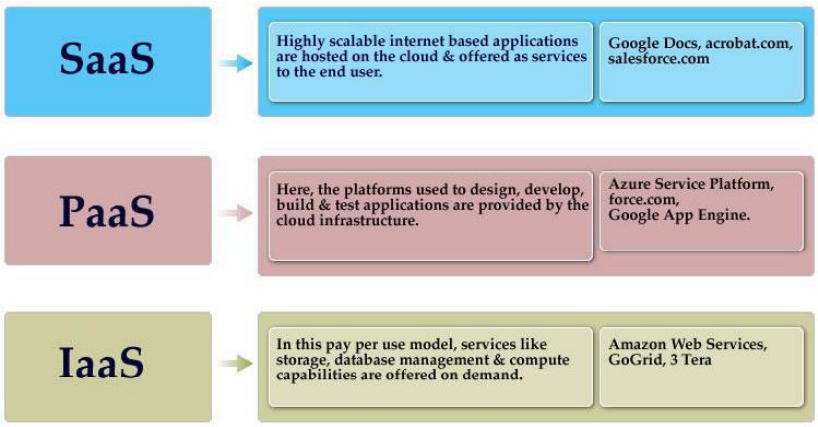

Figure 1: Cloud Taxonomy, Source: Torry Harris, Cloud Computing - An Overview

Deployment models

There are four models for cloud computing service deployment, regardless of the service or delivery model (IaaS, PaaS, or SaaS) adopted. These deployment models may have different derivatives which may address different specific needs or situations (Dustin Amrhein et al., 2010). The basic deployment models are public cloud, private cloud, community cloud and hybrid cloud (Dustin Amrhein et al., 2010, Grance, 2010, Mell and Grance, 2009a, Catteddu and Hogben, 2009).
A public cloud is characterized as being available from a third party service provider via the Internet, and is a cost-effective way to deploy IT solutions, especially for small or medium sized businesses. Google Apps is a prominent example of a public cloud that is used by many organizations of all sizes. A private cloud offers many of the benefits of a public cloud computing environment, such as being elastic and service based, but is managed within an organization. Private clouds provide greater control over the cloud infrastructure, and are often suitable for larger installations. A private cloud can actually be handled by a third-party provider, e.g. Government Cloud to store both applications and data of government agencies in a completely segregated environment, both logically and physically. A community cloud is controlled and used by a group of organizations that have shared interests, such as specific security requirements or a common mission. The United States federal government is one of the biggest users of a community cloud: built on Terremark's Enterprise cloud platform and it has allowed the government to rapidly deploy very specific applications, all of which are all linked to the U.S. government's official web portal USA.gov. Finally, a hybrid cloud is a combination of a public and private cloud – typically, non-critical information is outsourced to the public cloud, while business-critical services and data are kept within the control of the organization (Sean Marston et al. 2011)

Barriers to cloud computing

Organizations which consider adopting cloud based services must also understand the many major problems of information policy, including issues of privacy, security, reliability, access, and regulation. The major security challenge with clouds is that the owner of the data may not have control of where the data is placed (Singh and Shrivastava,). Some of the challenges are explained below.

Misunderstanding of responsibilities: In a traditional environment the security of data is entirely the burden of the company owning data. In the cloud computing environment, the responsibilities are divided between the two actors: the cloud provider and the client. There is a tremendous potential for misguided risk management decisions if cloud providers do not disclose the

extent to which the security controls are implemented and the consumer knows which controls are further needed to be adopted. Further, different kinds of cloud services adopted mean different responsibilities for the service provider and the customer. If an IaaS service model is adopted, then the provider is responsible for physical security, environment security and the virtualization software security, whereas the consumer is responsible for securing everything else above this layer including operating system, applications and data.

Data security and confidentiality issues: One of the biggest security concerns people have when moving to the cloud is related to the problem of keeping data secure and confidential. In this respect, some particular problems arise: who can create data, where the data is stored, who can access and modify data, what happens when data is deleted, how the back-up is done, how the data transfer occurs, etc.

Lack of Standards: The immaturity of this technology makes it difficult to develop a comprehensive and commonly accepted set of standards.

Interoperability issues: Additionally, at one time one company may have multiple cloud providers for different services which have to be interoperable. In time, for different reasons, companies may decide to move their services to another cloud and in such a case the lack of interoperability can block or raise heavy obstacles to such a process. Cloud providers may find the customer lock-in system attractive, but for the customers interoperability issues mean that they are vulnerable to price increases, quality of services not meeting their needs, closure of one or more cloud services, provider going out of business, disputes between with the cloud provider.

Reliability breakdowns: Another important aspect of the cloud computing is the reliability or availability of services. The breakdown of an essential service operating in a cloud has an impact on many clients. For example, in April 2012 there was a Gmail disruption that made Gmail services unavailable for almost 1 hour. These incidents are not rare and evidence the customer lack of control over their data. The irony is that, in terms of reliability, cloud providers have set high standards which are rarely achieved in an internal environment.

Malicious insider: A malicious insider is a person motivated to create a bad impact on the organization's mission by taking action that compromises information confidentiality, integrity, and/or availability. When sensitive data is processed outside the enterprise the organizational managers are less immediately aware of the nature and level of risk and they do not possess quick and direct capability to control and counter these risks.
Cloud computing adoption studies

Many organizations of different kind has started to adopt the cloud computing services at different levels of implementations. There are few studies on cloud computing adoption by using some technology acceptance models in different industries that includes mostly IT industry. Most of the organizations intend or is in the planning process of adopting loud services since it involves some sort of concern such as security and privacy, regulatory compliances, etc. Deploying cloud computing in an enterprise infrastructure bring significant security concerns. Successful implementation of cloud computing in an enterprise requires proper planning and understanding of emerging risks, threats, vulnerabilities, and possible countermeasures. Adoption of cloud computing for education is on the increase especially in US, UK, and African Countries. However, For Asian countries, the concept is still new and higher educational institutions are considering it.

Conclusions and Discussions

As with any computing model, the technological landscape is rapidly evolving in cloud computing. Even though it might be impossible to assume all the technological changes in future, the economic forces shaping this phenomenon, in contrast, are very logical and almost inexorable in nature. Many technical researches are being carried out to over the challenges in adopting cloud computing. However, from the user point of view, the study on cloud computing is rare and users are very concerned about the use of cloud computing and there is no such study yet in Sri Lanka. Based on their decades of experience, corporate computing has developed its own standards regarding the reliability, stability and security of its information systems, and comprehensive answers need to be provided on all fronts before cloud computing can become a viable option for the larger corporate customers.

Many governments are becoming increasingly interested in cloud computing and Sri Lanka government also started cloud platform to provide services to the public and organizations recently. While there is an impressive amount of literature on cloud computing in computer science, there is still a dearth of literature in the IS area that look at cloud computing.

One of the goals of this paper is to start that process by presenting a starting list of the various issues at the intersection of the business and the technology involved in cloud computing. Since the cloud computing is new thing to country like Sri Lanka, it is better to study this concept and see the potential of implementing cloud solutions to meet different organizations' computing needs.

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