Cloud Computing: The Next Computing Paradigm

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Abstract

Cloud computing provides a new way to build applications on on-demand infrastructures instead of building applications on fixed and rigid infrastructures. This paper discuss the methodology for cloud computing paradigm shift, that is, from the conventional computing to leveraging the features of cloud computing. This includes the way on how to redesign, build and deliver applications as well as the architectural challenges that must be taken for consideration when adopting and migrating into cloud computing.

Keywords: *cloud computing, paradigm shift, Cloudonomics*

1. Introduction

The emergence of cloud computing promises to increase the speed with which applications are deployed, innovates and lower costs, particularly in the business world. Productivity levels of businesses of all sizes have ultimately increased since the cloud computing solutions have relieved them with many information technology problems such as issues related with on-premise software, increased efficiency, streamlined operations, and improved sales and marketing strategies. Cloud computing solutions only requires access to the Internet and a Web browser, and the heavy lifting of the software and hardware of the individual computer work station is removed. The "cloud" is then responsible for the maintenance and upkeep of the software provided, thereby removing time-consuming and costly IT responsibilities from the business enterprises [6].

Cloud Computing is defined as an Internet-based computing, whereby shared resources, software, and information are provided to computers and other devices on demand. It is already a permanent fixture of consumer oriented services such as email, storage and social media [4]. The opportunities provided by cloud computing becomes available to enterprises of all sizes that enables them to deliver more scalable and resilient services to employees, partners and customers at lower cost and with higher business agility [1].

In this paper, we discuss the challenges and promises cloud computing has to offer that conventional computing models cannot. A methodology is defined as basis for the paradigm shift from conventional computing to leveraging the features and capabilities of cloud computing. This includes the way on how to redesign, build and deliver applications as well as the architectural challenges that must be taken for consideration when adopting and migrating into cloud computing [5].

The rest of this paper is organized as follows: Section 2 explains the cloud computing paradigm; Section 3 outlines the methodology for the paradigm shift from conventional computing into cloud computing; and the concluding remarks in Section 4.

2. The Cloud Computing Paradigm

2.1 Cloud Services

Cloud service offerings are classified into three delivery models: the Infrastructure as a Service (IaaS); the Platform as a Service (PaaS); and the Software as a Service (SaaS) [1, 3, 4, 6].

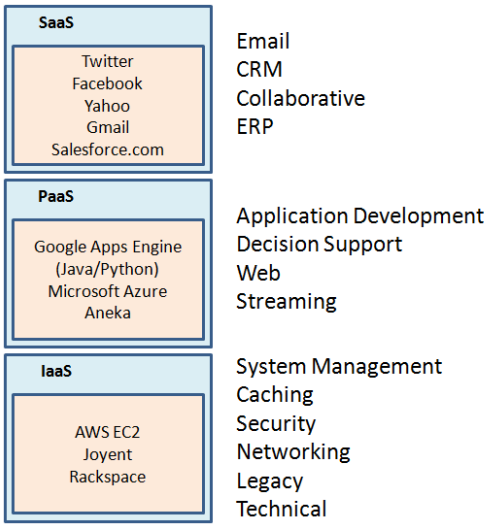

Figure 1. Cloud Computing Service Offerings

Software as a Service (SaaS) offers complete and finished applications on demand. A single instance of the software runs on the cloud and services multiple end users or client organizations. It is a model of software deployment where an application is hosted as a service provided to customers across the Internet. By eliminating the need to install and run the application on the customer's own computer, SaaS alleviates the customer's burden of software maintenance, ongoing operation, and support. Most widely used examples of SaaS include Gmail, Google Docs, and Salesforce.com.

Platform as a Service (PaaS) offers an operating system and can provide for every phase of software development and testing as well as suites of programming languages that users can use to develop their own applications. Commercial examples include Microsoft Windows Azure and Google App Engine.

Infrastructure as a Service (IaaS) offers end users direct access to processing, storage, and other computing resources over the network. Examples of IaaS include Amazon Elastic Compute Cloud (EC2), Joyent, Rackspace, and IBM Computing on Demand.

Figure 2 illustrates the Cloud computing services provisioning indicating virtualization of resources. For SaaS, the service levels, security, governance, compliance, and liability expectations of the service are contractually stipulated, managed to, and enforced to the provider. For PaaS or IaaS, the consumer's system administrators has the responsibility to effectively manage this issues, with some offset

expected by the provider for securing the underlying platform and infrastructure components to ensure basic service availability and security. It should be clear in either case that one can assign/transfer responsibility but not necessarily accountability for both consumers and providers.

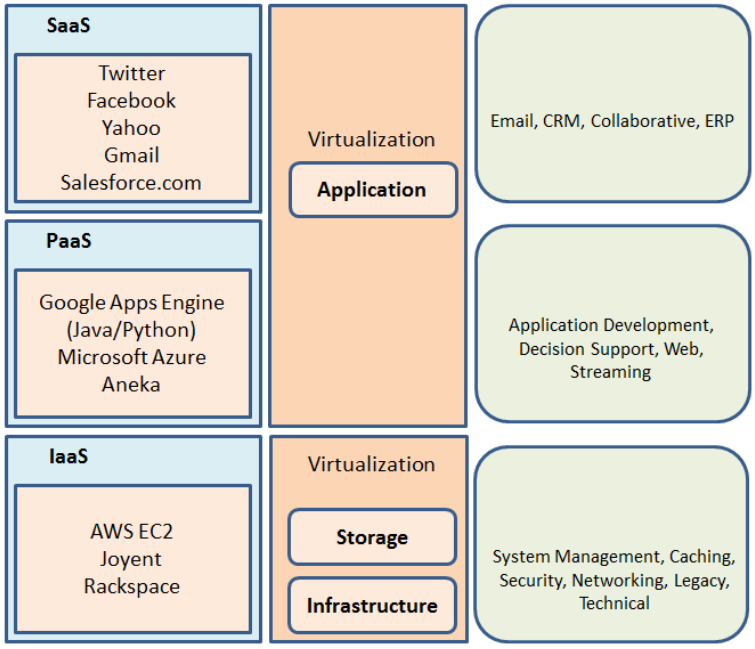

Figure 2. Cloud Computing Services Provisioning

2.2 Cloud Application Deployment Models

Cloud computing architects must take into consideration the three cloud application deployment and consumption models: public, private, or hybrid clouds. Each offers complementary benefits, and has its own trade-offs. There is one another type of cloud deployment model known as community cloud which is being used in some instances [1, 3, 4, 6].

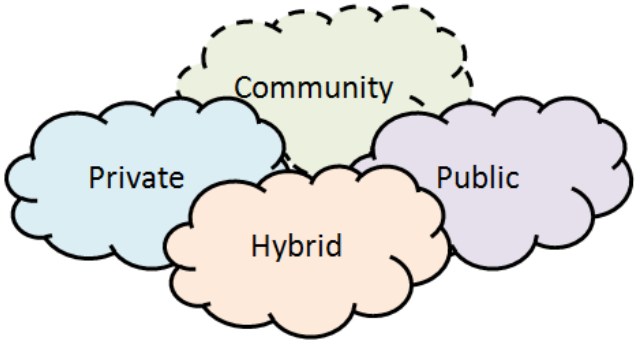

Figure 3. Cloud Application Deployment Models

Public Clouds: Public clouds are owned and managed by Providers, and applications from different customers are likely to be mixed together on the cloud's servers, storage systems, and networks. Public clouds are most often hosted away from customer premises, and they

provide a way to reduce customer risk and cost by providing a flexible, even temporary extension to enterprise infrastructure.

Private Clouds: Private clouds are client dedicated and are built for the exclusive use of one client, providing the utmost control over data, security, and quality of service. The enterprise owns the infrastructure and has control over how applications are deployed on it. Private clouds may be deployed in an enterprise datacenter, and they also may be deployed at a co-location facility.

Hybrid Clouds: Hybrid clouds leverage both public and private cloud models. They can help to provide on-demand, externally provisioned scale. The ability to augment a private cloud with the resources of a public cloud can be used to maintain service levels in the face of rapid workload fluctuations. Enterprise Computing and private cloud extend outward to consume public compute resource for peak need or deliver on Industry cloud. Focus primarily on proprietary data centers, but rely on public cloud resources to provide the computing and storage needed to protect against unexpected or infrequent increases in demand for computing resources.

Community Clouds: Community clouds are tailored to a specific vertical industry, such as government, healthcare or finance, offering a range of services, including infrastructure, software or platform as a service.

2.3 Characteristics of Cloud Computing

There are five essential characteristics that describe and differentiate Cloud services from conventional computing approaches [6, 7]:

On-demand self-service. Users can directly and automatically provision computing capabilities such as server time and network storage as needed without requiring actual interaction with a service provider.

Broad network access. Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, laptops, and PDAs) as well as other conventional or cloud-based software services.

Resource pooling. The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. Resources include storage, processing, memory, network bandwidth, and virtual machines.

Rapid elasticity. Capabilities can be rapidly and elastically provisioned for unlimited and can be purchased in any quantity at any time.

Measured service. Resource usage can be monitored, controlled and optimized automatically through metering capabilities.

Cloud services are often but not always utilized in conjunction with, and enabled by, virtualization technologies.

3. Cloud Paradigm Shift Methodology

The paradigm shift from conventional computing to cloud computing is implemented in three main stages. The methodology is depicted in Figure 4.

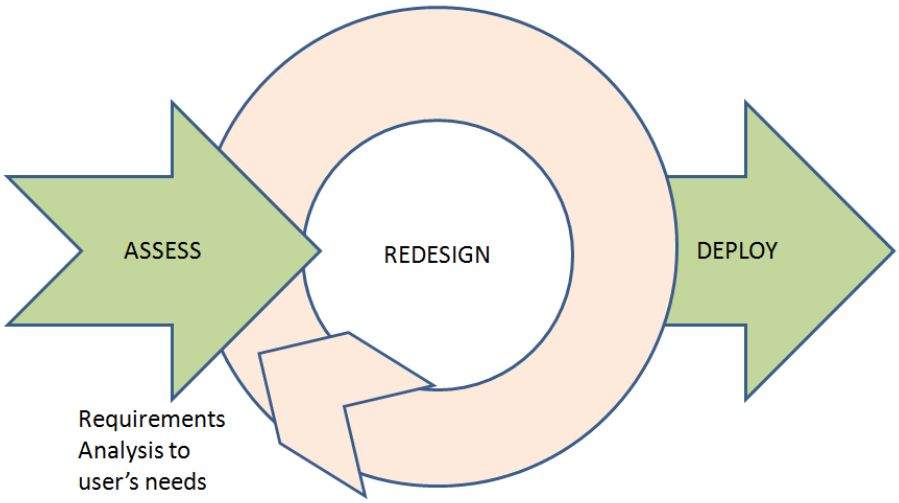

Figure 4. Three Step Paradigm Shift to Cloud Computing

The first stage includes assessments to understand and analyze the issues concerning the migration at the application level, design, code, architecture, or usage levels. This includes assessments of the Cloudonomics [2], migration costs, recurring costs, database data segmentation, database migration, functionalities required, and the non-functional requirements support. The dependencies and solutions to handle them are also included in this stage. The deliverables of this stage are the specified and validated user requirements that leads to the enterprise's cloud architecture design, thus identifying the desired functionalities that they need.

The second stage includes the redesign, re-architect, and re implementation on the cloud. Functionalities identified in the previous stage are implemented as additional or modifications for the existing or current conventional computing an enterprise is using. The features and advantages of cloud computing in this phase are leveraged to augment enterprise applications in small ways. This exploits additional cloud features, autoscaling, storage, bandwidth, and security.

This stage also includes optimization compliance with standards and governance. If there are requirements or functionalities that dissatisfy standards and needs of the users, there will be rework and iteration.

Finally, after some iterations and optimizations, cloud computing is deployed and consumed. A roadmap for leveraging new cloud features is also developed at this stage delivering best return of investment.

4. Conclusions

Cloud computing offers 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. It holds a considerable promise as a transformative technology that can change the very nature of computing, specifically to business enterprises. Assessment of cloud computing relative merits requires a clear understanding of its key concepts and its underlying economics. A three-step is outlined as basis for the paradigm shift from conventional computing to leveraging the features and capabilities of cloud computing. This includes the way on how to redesign, build and deliver applications as well as the

architectural challenges that must be taken for consideration when adopting and migrating into cloud computing.

Acknowledgements

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