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Critical analysis of Existing Cloud Computing Techniques

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Abstract

Cloud computing is one of the emerging technologies that will lead to the next generation of Internet. It provides optimized and efficient computing through enhanced collaboration, agility, scalability, and availability. In this paper, the evolution of the Cloud is discussed, the cloud computing model is explained, a set of cloud computing infrastructure metrics is listed, the cloud service model architectures are described and cloud service models are analyzed, and intriguing facts about cloud computing status and future are shared.

Keywords:—*Cloud Computing; SaaS; PaaS; IaaS; Google Apps; Oracle Fusion; Microsoft Azure; Amazon EC2*

I. Introduction

The cloud computing paradigm enhances collaboration, agility, scalability, and availability for end-users and enterprises. It provides optimized and efficient computing platform, and reduces hardware and software investment cost, as well as carbon footprint. In this paper, the evolution of sharing on the Internet is discussed, the cloud computing model and the cloud delivery architecture models are explained, exemplary implementations of cloud services are analyzed, and intriguing reports and facts about the current status of cloud computing and its future are shared.

II. Evolution of the Cloud

The evolution of sharing on the Cloud Figure 1 went through: networking, network sharing, information sharing, resources sharing, and services sharing [1]. The first stage of the Cloud was around networking, the TCP/IP abstraction. Multiple regional networks, linking computers, were built at universities and national laboratories. Their inter-networking with TCP/IP led to network sharing and the emergence of the Internet and its worldwide adoption. The second stage of the Cloud was around documents, the WWW data abstraction. The HTML format, the HTTP protocol, and the Mosaic browser were adopted by universities for document exchange and then worldwide for information sharing. Then, grid computing emerged with the creation of standards and software for remote resources sharing and collaboration, exclusively utilized for highly scalable High Performance Computing (HPC) jobs. The newest stage of the Cloud, cloud computing, has emerged to provide services sharing by abstracting infrastructure complexities of servers, applications, data, and heterogeneous platforms.

According to the U.S. Government's National Institute of Standards and Technology (NIST), cloud computing is a "model for enabling 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" [2]. The origin of the term comes from the early days of the Internet where the network was depicted as a cloud (Figure 2).

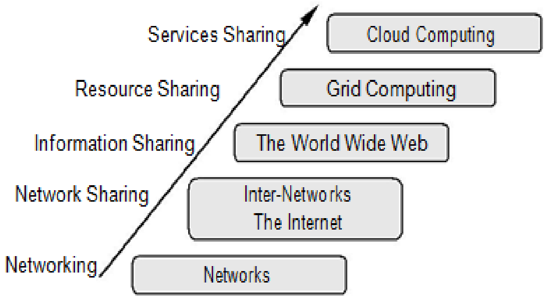

Figure 1. The Evolution of Sharing on the Cloud.

Cloud computing is an Internet-based delivery model for Information Technology (IT) services that enhances collaboration, agility, scalability, and availability. The optimized and efficient computing is provided through a virtualized technology infrastructure, which is maintained and secured for the users.

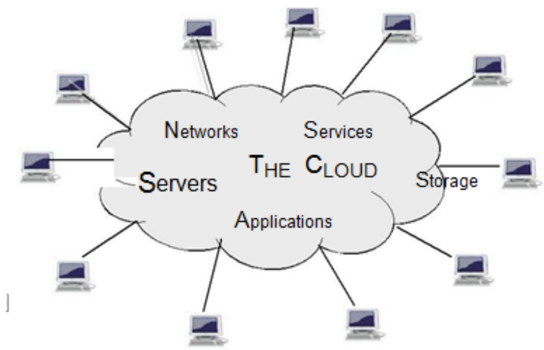

Figure 2: Cloud Services

Cloud computing services are offered on a pay -as-you-go basis and assure considerable reduction in hardware and software investment costs, as well as in carbon footprints and energy costs. Currently, cloud computing is more attractive for Web infrastructure, collaboration, development and testing, high performance computing applications, but still less attractive for database and transaction processing, and regulated applications.

III. The Cloud Model

The Cloud model is composed of five essential characteristics, three service models, and four deployment models [2] as illustrated in Figure 3.

The essential cloud characteristics are on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service. Computing capabilities, such as server time and network storage, can be unilaterally provisioned or de-provisioned as needed and automatically. They are available over the Internet and accessible through heterogeneous client platforms, such as laptops and mobile phones. The computing resources are pooled and dynamically assigned and reassigned to serve multiple consumers. The capabilities appear to be unlimited, as they can be rapidly and elastically provisioned to quickly scale out and rapidly released to quickly scale in. The resource use is automatically controlled and optimized by leveraged metering capabilities.

The cloud service models are Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). SaaS allows use of applications that run on the cloud infrastructure and are accessible from various client devices. PaaS allows creation of applications with supported programming languages and tools, and their deployment onto the cloud infrastructure. IaaS allows to provision processing, storage, networks, and other fundamental computing resources to deploy and run software, including operating systems and applications.

With SaaS, the users do not manage or control even the individual application capabilities. With PaaS they have control over the deployed applications and the hosting environment configurations. With IaaS, users do not manage or control the underlying cloud infrastructure, but they have control over the operating systems, deployed applications, storage, and limited control on networking components.

The cloud deployment models are private, community, public, and hybrid. Private clouds are operated for individual organizations. Community clouds are operated for organizations with shared interests. Public clouds are available to the general public or large industry groups.

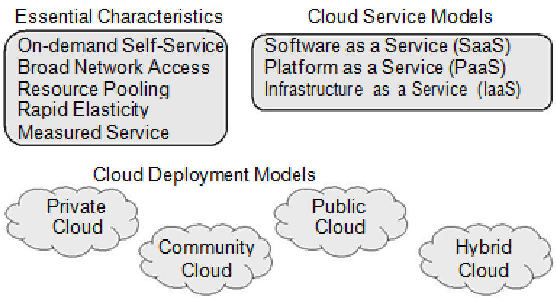

Figure 3. The Cloud Model

Hybrid clouds comprise unique clouds, bound by technology that enables interoperability amongst the clouds.

The relative efficiencies of the different cloud computing models can be determined by measuring and analyzing the following set of cloud computing infrastructure metrics.

Hardware costs – measured by determining the virtualized environment needed to consolidate a traditional infrastructure of independent servers. The consolidation goal is to increase the efficiency by reducing the overall infrastructure costs through elimination of redundant and under-utilized servers.

Software costs – the dominant costs are determined by the suite of virtualization software and service management software. The virtualization software provides the intelligence for server consolidation and improving system utilization by executing different workloads on a single server. The service management software facilitates efficient workflows, administration and management of multiple workloads, and automated service provisioning.

Real-time provisioning costs – measured by determining the elapsed time for deploying new systems, upgrading existing systems, or migrating to a new consolidated cloud computing platform. Real-time provisioning is usually accomplished via automated tools that may also be integrated into the service management system.

System administration costs – realized by measuring the efficiency of managing virtual servers. Cloud computing models have more virtual servers and comparably few physical servers. In addition, in today's environment, virtual servers are more complex to administer than physical ones. Effective system administration in the cloud computing model would require a paradigm shift from the traditional centralized approach to a fully distributed approach neatly integrated into virtual servers.

In the current environment, clients of Cloud providers can accrue significant reductions in overall IT costs by utilizing private cloud infrastructure compared to public cloud infrastructure. On the other side, Cloud providers accrue the most savings with public cloud infrastructure.

A critical aspect of cloud computing is assessing the risks, such as data integrity, recovery, privacy, and tenant isolation, as the traditional requirements for IT security become more complicated by the externalization of the security model.

IV. Cloud Service Model Architectures

The cloud computing delivery architecture models define the boundaries and the fit of the services, and how the set of service models align and interact [3].Each *aaS model is a self -contained solution stack of integrated functionality, where IaaS provides the foundation and the other two – PaaS and SaaS – in turn build upon IaaS cloud service model architectures may be comprised by any logical combination of the three *aaS service models over the cloud infrastructure. For example, a SaaS service model could stack directly over the cloud infrastructure, or a PaaS service model could stack over IaaS over the cloud infrastructure.

IaaS includes the entire infrastructure resource stack (from facilities to hardware), has capability to abstract resources and deliver physical and logical connectivity to them, and provides application interfaces for interaction with the infrastructure. PaaS is build upon IaaS, adding a layer of integration with application development frameworks (middleware capabilities and functions), allowing developers to build applications coupled to the platform. SaaS in turn is built upon the underlying IaaS and PaaS stacks, providing a self-contained operating environment for delivery of the entire user experience (content and its presentation, applications, and management capabilities).

V. Exploration of Implemented Cloud Services

In the cloud computing paradigm, virtualization and management of standard enterprise IT solution stacks are offered through the three levels of services: SaaS, PaaS, and IaaS, which provide a composite view of cloud service model architectures.

A. Software as a Service

In a SaaS cloud, a given application running at a data center is offered as service instances in real-time to several end-users or organizations on demand. The basic SaaS architecture is included as part of the service model. SaaS applications may facilitate communication, collaboration, business processes, customer relationship management (CRM), enterprise resource planning, and human resources. Examples of the SaaS paradigm include Google Apps, Microsoft Exchange, Cisco WebEx Weboffice, Oracle CRM On Demand, SalesForse.com, and Yahoo Mail.

The Google SaaS cloud includes communication and collaboration applications for end-users and organizations. Each tool is hosted by Google and offered on demand as service instances to multiple users. Google Apps [4] tools include Gmail; Google Calendar for agenda management, scheduling, shared online calendars and mobile calendar synchronization; Google Docs for documents, spreadsheets, drawings, and presentations sharing; Google Groups for secure coding of free Web pages for intranets; and Google video for private, secure, hosted video sharing. Other Google Apps include integrated applications built by independent software developers and hosted at Google. The SaaS presentation modality of Google Apps is a two steps process: the user initiates a download and then an install. The current SaaS presentation platform supports: Microsoft Internet Explorer 7.0+, Mozilla Firefox 3.0+, Google Chrome 4.0+, and Safari 3.0+. The SaaS Application Programming Interface (API) is integrated into the Google universal toolbar. The API therefore remains open while the browser is running, and controls how the software application in the Cloud is harnessed by the end-user.

B. Platform as a Service

PaaS is typically a suite of low-level software, which provides a platform for application-level development and deployment. The basic PaaS architecture is included as part of the service model architecture illustrated in Figure 4. It is offered as a service to developers to facilitate the complete software life cycle without the need to purchase standard enterprise management tools and infrastructures (i.e., platform virtualization). The low-level software may include application software, middleware, databases, and development tools. Developers interface with the platform through an API and a specific language (e.g. Java, C#, or Python). The interface (e.g. API) provides developers with the capability to harness specific platform features provided as part of the virtualization over the Cloud. The platform features may include middleware and development tools, operating systems, and relational database services, depending on the PaaS offerings.

Examples of PaaS offerings include Oracle Fusion Middleware, Google AppEngine, Amazon Web Services, Facebook, and Microsoft Azure. Figure 5 illustrates the fundamental architecture of a PaaS cloud for UI, SOA, and BPM service offerings.

In particular, the Oracle Fusion Middleware PaaS offering [5] includes user interface (UI) technologies, service oriented architecture (SOA) technologies, and business process management (BPM). Above the middleware typically there is a suite of APIs, which provide developers with the capability to interact with the virtual platform components (e.g. UI, SOA, and BPM) over the Cloud.

C. Infrastructure as a Service (IaaS)

IaaS provides end-users and organizations with a suite of virtual hardware and associated software as services over the IaaS cloud. The basic IaaS architecture is included as part of the service model architecture illustrated in Figure 4. Typical virtual hardware includes servers, storage systems, routers, and switches. The associated software includes tools to present the virtual OS environment and file system capabilities over the Cloud. End-users interface with the services via a suite of APIs, provided as part of the IaaS offerings. Examples of IaaS offerings include IBM, Amazon Elastic Compute Cloud (EC2), Microsoft Azure, Rackspace Cloud, Telstra, and Sun.

Note that Microsoft Azure capabilities are now extended to include both PaaS and IaaS clouds. Its framework starts with a set of high -availability machines, designated as the “Fabric Controllers” (FCs) for the PaaS and IaaS clouds.

Each FC is configured with both a Host and Guest Virtual Machines (VM). Each VM includes Microsoft.Net Framework, WindowsServer Internet Information Services (IIS), and WindowsServer 2008 Enterprise.

Amazon Elastic Compute Cloud (EC2) is another example of an IaaS public cloud model. Key components of the architecture are Elastic Block Storage (EBS), Simple Storage Service (S3), Availability Zones and Regions, CPU Cores, Virtual Machines, Virtualization software, Amazon Machine Images, dynamic internal IP address, dynamic external IP address schemes and fixed elastic IP addresses.

In the Microsoft Azure environment, the Virtual Machines are provisioned using declarative statements. Declarative descriptions of application components (i.e., Worker Roles) are also employed to implement various networking models. The storage platform includes SQL Data Services and Azure Storage Service.

In the Amazon EC2 environment, the VM compute model is based on Xen Hypervisor VM. The VM can also be provided via a third party, such as RightScale. The networking model is implemented via declarative specifications of IP-address topology, including external and elastic IP addresses; the availability zones are designed to support high availability schemes. The storage model includes Elastic and Block Store in designated availability zones for persistent high availability; and the Simple Storage Service (SimpledB).

VI. Conclusions

IT enterprises face challenges such as increasing costs and constant need for capital investments; server sprawl, rising operational costs, ballooning energy costs and demands, increased complexity of systems and need for specialized talent to support them, variable recourse usage, demand for business process simplification, time to market pressures. The embrace of cloud computing or IT as utility service leads to more efficient use of IT hardware and software investments, on demand provisioning or de-provisioning, elastic scalability, usage based charging, service base provisioning, and agility. The cloud computing idea is appealing to end-users and organizations because of its simplicity. There is no need to invest in expensive hardware and software or pay for capacity that may not be used all the time. The users have access anytime, through any device, and from anywhere to software, platforms, and infrastructures, with no need to maintain and control them.

Both established and start-up enterprises have shifted to cloud computing; however there are still doubts about its cost efficiency and robustness. McKinsey's & Co. reported that cloud computing is beneficial for small and medium businesses, but questioned the model sustainability for large corporations [6]. Outages and security concerns flawed the prospects of cloud computing, too: power knock-out due to a lightning strike crippled the Amazon EC2 cloud infrastructure for hours [7], outages at Rackspace caused numerous customer applications to go down [8], and a hacker distributed 300 confidential Twitter's business affairs documents [9], stored on Google Apps. In addition, according to Greenpeace, cloud computing may hold sustainability implications as the cloud data centers are "massive storage facilities that consume incredible amounts of energy" [10].

Nevertheless, the concept of Cloud Computing is here to stay and the cloud providers are making sure their cloud services are safe. The governments realize the "flexibility, operational benefits and substantial cost savings that cloud computing can provide" [11]. For example, in May 2009, the Japanese Government announced the Kasumigaseki Cloud [12]; in September 2009, the US Government launched the Cloud Computing Mall for government agencies [13], and in January 2010, the UK Government introduced the G-Cloud government cloud infrastructure [14].

Forrester Research reported that Infrastructure and Operations (I&O) "needs to focus the second half of 2010's budget on growth" by transforming the desktops, retooling the data centers to support a path to the Cloud, and round out the efforts by industrializing the IT operations [15]. Cloud computing is no longer on the horizon; it has become the next logical step in enterprise computing. Organizations are focusing on managing information and no longer on managing infrastructure, by having their applications and storage, applications development environments, and even infrastructure and security available from the Cloud.

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