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Cloud Computing: An Overview

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Abstract. In order to support the maximum number of user and elastic service with the minimum resource, the Internet service provider invented the cloud computing. within a few years, emerging cloud computing has became the hottest technology. From the publication of core papers by Google since 2003 to the commercialization of Amazon EC2 in 2006, and to the service offering of AT&T Synaptic Hosting, the cloud computing has been evolved from internal IT system to public service, from cost-saving tools to revenue generator, and from ISP to telecom. This paper introduces the concept, history, pros and cons of cloud computing as well as the value chain and standardization effort.

Keywords: Cloud computing, Cloud Storage, Virtualization.

1 Definitions of Cloud Computing

Similar to e-commerce, cloud computing is one of the most vague technique terminologies in history. One reason is that cloud computing can be used in many application scenarios, the other reason is that cloud computing are hyped by lots of companies for business promotion. From the Hyper Cycle published by Gartner Group in 2008, we can see that the cloud computing is in the phase of fast growing.

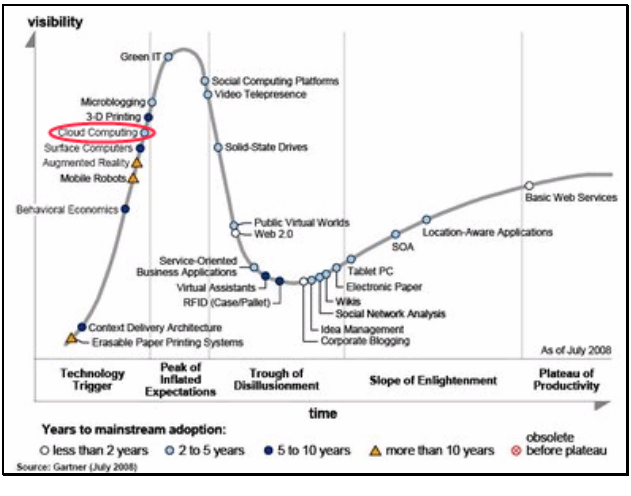

Fig. 1. Cloud computing is in the phase of fast growing

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In the MIT Centennial talk in 1961, John McCarthy said that "… The computer utility could become the basis of a new and important industry", which implied the underlying concepts of cloud computing. However the "cloud computing" as a whole is probably first introduced by Eric Schmidt in his talk on Search Engine Strategies Conferences in 2006[15].

Now there are lots of definitions and metaphors of cloud computing. From our points of view, *cloud computing is a kind of computing technique where IT services are provided by massive low-cost computing units connected by IP networks*. Cloud computing is rooted in search engine platform design. There are 5 major technical characteristics of cloud computing: (1) large scale computing resources (2) high scalability & elastic (3)shared resource pool (virtualized and physical resource) (4)dynamic resource scheduling and (5) general purpose.

2 History and Status

With the explosion of the Internet, tight pressure is put to the existing storage and computing facilities. The Internet service providers start to use the cheap commodity PCs as the underlying hardware platform. Various kinds of software technologies are invented to make these PCs work elastically, which has led to 3 major cloud computing styles based on the underlying resource abstraction technologies: the Amazon style, Google Style and Microsoft style.

- Amazon's cloud computing is based on **server virtualization** technology. Amazon released Xen-based Elastic Compute Cloud™ (EC2), object storage service (S3) and structure data storage service (SimpleDB)[12] during the 2006 – 2007, under the name Amazon Web Service™ (AWS)[9]. On-demand and cheaper AWS becomes the pioneer of Infrastructure as a Service (IaaS) provider.
- Google's style is based on **technique-specific sandbox**. Google published several research papers from 2003 to 2006[1-5], which outline a kind of Platform as a Service (PaaS) cloud computing. The platform, which is called Google App Engine™ (GAE), is released to public as a service in 2008.
- Microsoft Azure™ [10] is released in Oct. 2008, which uses Windows Azure Hypervisor (WAH) as the underlying cloud infrastructure and .NET as the application container. Azure also offers services including BLOB object storage and SQL service.

It's hard to judge which one is better, but apparently server virtualization is more flexible and compatible with existing software and applications; while the sandboxes put more restrictions on programming languages but less abstraction overhead. Currently, server virtualization is the most popular resource abstraction technique in cloud computing.

Except these public cloud services, lots of companies has experimented and/or implemented internal cloud computing systems. Cloud computing is already key strategy for IT vendors, ISP and telecom service providers. Even further, United States of America and Japan have made cloud computing the national strategy. The following table lists some of the adopters for each style.

Table 1. Three major cloud computing styles and their adopters, based on the resource abstraction techniques

Resource Abstraction Tech.	Adopters
Server Virtualization (Amazon Style)	Amazon EC2 (Xen), GoGrid (Xen), 21vianet CloudEx (Xen), RackSpace Mosso (Xen), Joyent (Accelerator), AT&T Synaptic (Vmware), Verizon CaaS (Vmware)
Technique-specific sandbox (Google Style)	GAE (Python & JVM), Heroku (Ruby), Morph Application Platform(Ruby)
Server Virtualization & Technique-specific sandbox (Microsoft Style)	Microsoft Azure (WAH & .NET)

3 Cloud Computing Architecture

Many organizations and researchers have defined the architecture for cloud computing. Basically the whole system can be divided into the core stack and the management. In the core stack, there are three layers: (1) Resource (2) Platform and (3) Application. The resource layer is the infrastructure layer which is composed of physical and virtualized computing, storage and networking resources.

The platform layer is the most complex part which could be divided into many sub-layers. E.g. a computing framework manages the transaction dispatching and/or task scheduling. A storage sub-layer provides unlimited storage and caching capability. The application server and other components support the same general application logic as before with either on-demand capability or flexible management, such that no components will be the bottle neck of the whole system.

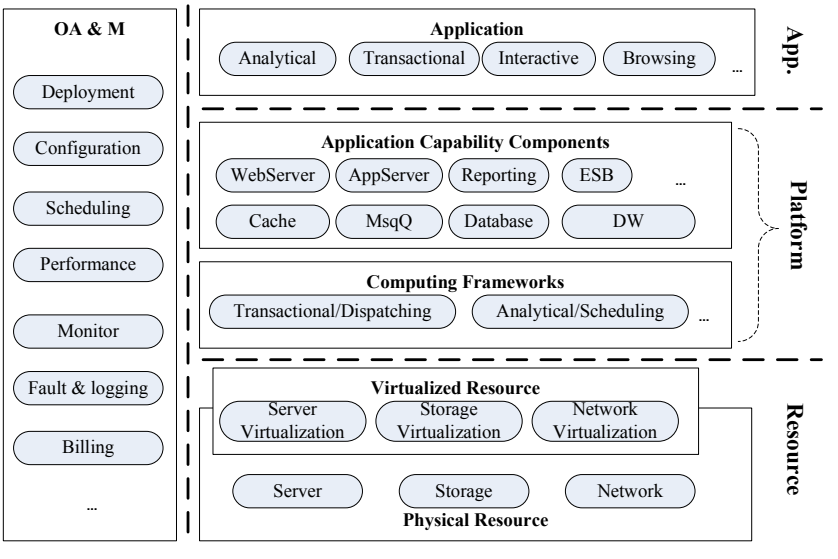

Fig. 2. The Reference architecture

Based on the underlying resource and components, the application could support large and distributed transactions and management of huge volume of data. All the layers provide external service through web service or other open interfaces.

4 Cloud Computing Categories

There are diverse dimensions to classify cloud computing, two commonly used categories are: service boundary and service type.

* From the service boundary's view, cloud computing can be classified as public cloud, private cloud and hybrid cloud. The public cloud refers to services provided to external parties. The enterprises build and operate private cloud for themselves. Hybrid cloud shares resources between public cloud and private cloud by a secure network. Virtual Private Cloud (VPC) services released by Google[8] and Amazon[9] are examples of Hybrid cloud.

* From the service type's view, cloud computing can be classified as Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS). SaaS provide services to end users, while IaaS and PaaS provide services to ISV and developers - leaving a margin for 3-party application developers.

5 Advantages and Risks

The cloud computing is a Win-Win strategy for the service provider and the service consumer. We summarize the advantages as below:

- ✓ **Satisfy business requirements on demand** by resizing the resource occupied by application to fulfill the changing the customer requirements.
- ✓ **Lower cost and energy-saving**. By making use of low cost PC, customerized low power consuming hardware and server virtualization, both CAPEX and OPEX are decreased.
- ✓ **Improve the efficiency of resource management** through dynamic resource scheduling.

However there are also some major challenges to be studied.

- ✓ **Privacy and security**. Customer has concerns on their privacy and data security than traditional hosting service.
- ✓ **The continuity of service**. It refers to the factors that may negatively affected the continuity of cloud computing such as Internet problems, power cut-off, service disruption and system bugs. Followed are some typical cases of such problems: In November 2007, RackSpace, Amazon's competitor, stopped its service for 3 hours because of power cut-off at its data center; in June 2008, Google App Engine service broke off for 6 hours due to some bugs of storage system; In March 2009, Microsoft Azure experienced 22 hours' out of service caused by OS system update. Currently, the public cloud provider based on virtualization, defines the reliability of service as 99.9% in SLA.
- ✓ **Service migration**. Currently, no regularity organization have reached the agreement on the standardization of cloud computing's external interface.

As a result, once a customer started to use the service of a cloud computing provider, he is most likely to be locked by the provider, which lay the customer in unfavorable conditions.

6 Value Chain of Cloud Computing

The following figure depicts the cloud computing value chain with related organizations and their functionalities.

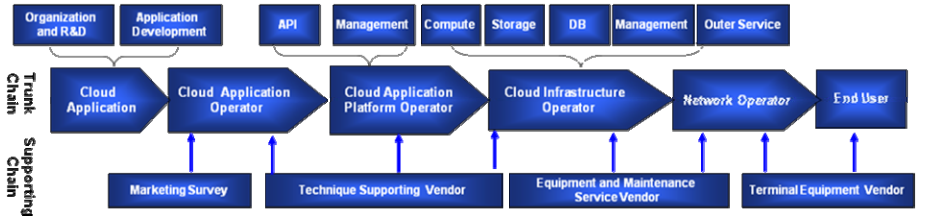

Fig. 3. The trunk and supporting value chain of cloud computing

- ✓ Cloud Applications: The driven force of cloud computing, which is different from traditional application module.
- ✓ Cloud Application Operator: Offers cloud computing products. In many cases, they are same as by application provider or platform provider.
- ✓ Cloud Application Platform Operator: Provides cloud application and development platform, such as GAE™ and Force.com™, etc.
- ✓ Cloud infrastructure operator: Provide infrastructure service, such as AWS™ and GoGrid.
- ✓ Network Operator: Provide network access service to the above platform operators and the end users.
- ✓ Technique supporting vendor: Offer technical support to players in this chain, including software development, testing, provisioning and operation.
- ✓ Terminal equipment vendor: Offer device maintenance service for all players in the chain.
- ✓ End Users: End users pays for the cloud services.

7 Standardization

Distributed Management Task Force[7] is an industry alliance composed by over 200 IT related corporations including IBM, EMC, HP, Cisco, Oracle and Microsoft, which is committed to develop, maintain and popularize the IT management system under enterprise context. DMTF has published Virtualization Management Initiative and Open Virtualization Format, and the latter is declared to be supported by major vendors. DMFT founded Open Cloud Standards Incubator at the year 2009, whose aim is to clarify the interoperability between several cloud systems.

OGF (Open Grid Forum) has started some work to discuss cloud computing related standards, which is a standardization organization like IETF aiming at promoting the standardization and best practice of distribute computing related techniques. CCI-WG (Open Cloud Computing Interface Working Group) is established to design resource management API for IaaS cloud services by OGF. Some cloud computing service providers like ElasticHosts, GoGrid, and FlexiScale have announced to adhere this API in the later developments.

Besides, SNIA (Storage Network Industry Association), CSA (Cloud Security Alliance) and OCC (Open Cloud Consortium) is now working on cloud storage, cloud security and cloud intercommunication standards respectively. In order to coordinate the work of above standardization organizations, OMG (Object Management Group) appealed that all the organizations maintain their own standards on http://cloud-standards.org.

PaaS and SaaS don't have related cloud computing standards yet. Most current systems exploit mature protocols and have variety kinds of service forms.

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