A Comparative Study of Different Deployment Models in a Cloud

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Abstract— Cloud computing is an emerging technology and organizations large and small are thinking about deploying their applications on the cloud. This paper aims at providing an overview of different types of cloud computing deployment models and which one to opt so that the security requirements and goals of the organization are met. This paper describes the characteristics of different types of cloud computing deployment models, viz. private, public, hybrid and community clouds. We have compared the private cloud and public cloud and listed the pros and cons of using one over the other.

Keywords— Cloud Computing, Public, Private, Hybrid, Deployment models

I. INTRODUCTION

Cloud computing has been defined by US National Institute of Standards and Technology (NIST) [1]as "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 cloud provider interaction ". Cloud Computing is a model where in on-demand access to the resources are provided to the users as they plug into the cloud provided that a network connection is available. Cloud computing provides a shared pool of resources, including data storage space, networks, computer processing power, and specialized corporate and user application. Services can be scaled larger or smaller; and use of a service is measured and customers are billed accordingly.

A. Cloud computing service models
1) Infrastructure as a service (IaaS):
Infrastructure as a service providers offer organizations services which include hardware, software, storage, networking, data center space, and various utility software elements on request on a pay-per-use basis.
2) *Platform as a service (PaaS):*
Platform as a service providers deliver a computing platform which include operating system, programming language execution environment, database, and web server. Application developers can develop and run their software solutions on a cloud platform without the cost and complexity of buying and managing the underlying hardware and software layers.
3) *Software as a service (SaaS):*
Software as a service providers install and operate application software in the cloud and organization (the client) rents or leases storage space from the SaaS provider to access the software from the cloud.

II. CLOUD COMPUTING DEPLOYMENT MODELS

Cloud computing deployment models are classified into 4 types

A. Public cloud
The public cloud, offer applications, storage and other services to the general public by a service provider. This is based on "pay-as-you-go" model. A public cloud is constructed with a view to offer unlimited storage space and increased bandwidth via Internet to all businesses. Public clouds are owned, hosted and operated by third-party service providers. A public cloud caters to all kind of requirements from small, medium or big businesses. A public cloud is the most simplest to setup as it liberates that subscriber from woes of hardware, application and bandwidth expenses. Enterprises pay for only those condiments which they are utilizing. Users have to pay a monthly bill for public cloud services. Public cloud functions on the prime principle of storage demand scalability, which means it requires no hardware device. Popular examples of public clouds include Amazon Elastic Cloud Compute, Google App Engine, Blue Cloud by IBM and Azure services Platform by Windows.

Public cloud caters to four basic characteristics [2] that are as follows:

Flexible and Elastic Environment: Public clouds like Google App engine or Amazon elastic cloud compute offers its users highly flexible cloud environment. They enable users to share and store data as per their personal capacities. They can decide what to share and what not to share with their clients.

1) *Freedom of Self-Service:* Public clouds encourage users to create a cloud on their own without taking anyone's help. These are pre-configured clouds existing on Internet. The only thing businesses that wish to opt for public cloud need to do is to visit public cloud portals and get started with it. You don't have to depend upon on any third party help to create or run this type of cloud. It will be managed and handled by you as you will be the prime proprietor of it.

2) *Pay for what you use:* This particular characteristic enables cloud technology more accessible for businesses to work in a synchronized fashion. The more you use cloud services, better will be the future business prospects. However, payment is charged on the basis of cloud services used by users.

3) *Availability and Reliability:* Yet another feature of public cloud is that, it is available to all and believes in agility. You can catch up with your work any time you wish and from any corner of the globe. Not only users become more independent in running important business tasks but also more efficient in strengthening customer relations across the globe.

B. *Private cloud*

Private cloud is a cloud infrastructure build exclusively for a single organization, deployed within certain boundaries like firewall settings whether managed internally or by a third-party and hosted internally or externally. Users are charged on the basis of per Gigabyte usage along with bandwidth transfer fees. Data stored in the private cloud can only be shared amongst users of an organization and third party sharing depends upon trust they build with them. Popular examples of private cloud include Amazon Virtual Private Cloud (Amazon VPC), Eucalyptus Cloud Platform, IBM SmartCloud Foundation and Microsoft Private Cloud

There are two variations of private clouds [3]:

- *On-Premise Private Cloud:* This format, also known as an "internal cloud," is hosted within an organization's own data centre. It provides a more standardized process and protection, but is often limited in size and scalability. Also, a firm's IT department would incur the capital and operational costs for the physical resources with this model. On-premise private clouds are best used for applications that require complete control and configurability of the infrastructure and security.

- *Externally-Hosted Private Cloud:* This private cloud model is hosted by an external cloud computing provider. The service provider facilitates an exclusive cloud environment with full guarantee of privacy. This format is recommended for organizations that prefer not to use a public cloud infrastructure due to the risks associated with the sharing of physical resources

Some of the characteristics of private cloud [4] are:

1) *Enhanced Security Measures:* Security has become one of the primary concerns for many organizations especially for financial institutions. Let's take a bank or a mortgage company, the confidentiality and security of their critical data is the utmost concern. Virtual private cloud computing comes equipped with a customizable and thorough firewall and a plethora of security tools which ensure maximum protection against unauthorized use, hacking and other such malicious attempts.

2) *Dedicated Resources:* The essence of private cloud is "no compromise". As a subscriber to private cloud computing an enterprise has its own dedicated resources such as processor time and data buses which ensure optimum performance.

3) *Greater Customization:* Private cloud services are acquiescent and customizable so they can be molded to suit the exact requirements of an enterprise. This in turns bestows the enterprise with more control over their data.\

C. *Hybrid cloud*

Hybrid clouds combine the advantages of private and public clouds, offer flexibility, control and security of multiple deployment models as shown in the Figure 1. IT organizations use hybrid clouds to employ cloud bursting for scaling across clouds.

Cloud bursting [9] is an application deployment model in which an application runs in a private cloud or data centre and "bursts" to a public cloud when the demand for computing capacity increases. A primary advantage of cloud bursting and a hybrid cloud model is that an organization only pays for extra compute resources when they are needed. Hybrid cloud architecture requires both on-premises resources and off-site (remote) server-based cloud infrastructure.
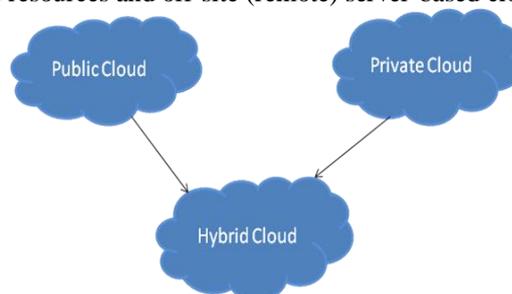
Figure 1: Hybrid Cloud as a combination of Public Cloud and Private Cloud

Some of the characteristics of hybrid clouds [5] are:

1) *Optimal utilization:* The available server resources in typical data centres are actually used from 5-20%. This is because of peak loads which are ten times higher than that of the average load. Hence, servers are mostly idle - generating unnecessary costs. Hybrid clouds can increase server utilization by scaling out to public resources to handle crowds.

2) *Data centre consolidation:* Instead of providing the capacity to cope for worst-case scenarios, a private cloud only needs resources in average cases. The option to burst out allows server consolidation and hence resulting in reduction of operating costs. In particular, this includes the costs for hardware, power, cooling, maintenance, and administration.

3) *Risk transfer:* The companies themselves are responsible for keeping up and running their data centre and private cloud. The public cloud provider has to ensure a high uptime for their service. Using a hybrid cloud model, "the risk of misestimating workload is shifted to the cloud vendor from the service operator". Most of the cloud providers have service level agreements which ensure an uptime of more than 99.9% per year, i.e., a downtime of max. 9 hours per year.

4) *Availability:* The high availability in the corporate data centre is difficult and expensive, because it requires redundancy, backups, and geographic dissemination. Especially in companies where IT is not the core business, the expertise in this area is rather limited. In a hybrid cloud environment, the public cloud can scale up or take over operations completely if the company's data centre is unavailable due to failures or Distributed Denial of Service (DDoS) attacks.

D. *Community cloud*

The cloud infrastructure is shared between the organizations with similar interests and requirements whether managed internally or by a third-party and hosted internally or externally. The costs are spread over fewer users than a public cloud (but more than a private cloud), so only some of the cost savings potential of cloud computing are realized. This may help limit the capital expenditure costs for its establishment as the costs are shared among the organizations.
 For example, all the government agencies in a city can share the same cloud but not the non government agencies.

III. PUBLIC CLOUD VS PRIVATE CLOUD

Public Cloud and Private Cloud have their own distinct characteristics. We compare the Public Cloud and Private Cloud [6, 7] as shown in the Figure 2, to get a clearer understanding of using one over the other.

- *Accessibility:* A private cloud, functions independently for an organization and that too behind firewall settings does prove to be accessible. By stating this, we mean that a private cloud cannot be accessed from anywhere and at any point of time. It is completely managed by the users working for an organization. Public Cloud architecture is built with the view to create an accessible business environment that can be shared and accessed from any part of the globe and at any time of the hour using internet

- *Scalability:* Private cloud gives scalable business environment, public cloud infrastructures is that they are typically larger in scale than a private cloud, which provides clients with seamless, on-demand scalability.

- *Data security risks:* Security of data is utmost priority of cloud providers so that they offer customers a reliable and flexible cloud environment. Data security risks of private cloud are less as compared to the one stored in public cloud.

- *Initial Cost:* Private cloud Initial cost is expensive, but gets minimal at later stages of using it as a service. In a public cloud, initial cost is minimal, but if data is stored for a long period of time, it proves to be expensive.

- *Availability and reliability*: These are the two factors that make public cloud computing service more popular. The reason being, it is available to users via web installed at a given server off-premises.

- *Data Storage:* Larger amounts of data can be stored in the private cloud for a lower cost. Many different types of data can be stored in the public cloud however large amounts stored for long periods tend to get pricey.

- *Public clouds have better utilization rates:* With private cloud, your organization still has to build and maintain all kinds of servers to meet spikes in demand across various divisions or functions. Public cloud offers the same spare demand on a pay-as-you-need-it basis.

- *Public clouds offer greater elasticity:* An organization will never consume all the capacity of a public cloud, but organizations private cloud is another matter entirely. Public cloud offers greater elasticity compared to private cloud

- *Private clouds tend to use older technology than public clouds:* You may have spent hundreds of thousands of dollars on new hardware and software for a private cloud, but try getting your organization to agree to that every year .Hence private clouds tend to use older technology compared to a public cloud

- *Public clouds get enterprises out of the "datacenter business":* establishing private cloud probably gets you in deeper into the DC business than with traditional on-premises servers.

For instance, the public cloud is like an apartment building filled with multiple tenants while a private cloud is like an apartment building you have to yourself.
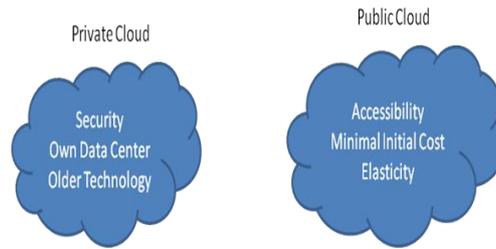
Figure 2: Comparison between Public Cloud and Private Cloud

IV. WHICH DEPLOYMENT MODEL TO CHOOSE AMONG PUBLIC, PRIVATE AND HYBRID CLOUD

A public cloud is the obvious choice when

- Public Cloud Computing is the easiest of cloud solutions to setup and maintain and is the preferred choice of most small scale and start-up enterprises, that don't require high data security measures. These companies often don't have much capital and have less risk in losing information due to theft or security breaches.
- Your standardized workload for applications is used by lots of people, such as e-mail.
- You need to test and develop application code.
- You have SaaS (Software as a Service) applications from a vendor who has a well-implemented security strategy.
- You need incremental capacity (the ability to add computer capacity for peak times).
- You're doing collaboration projects.
- You're doing an ad-hoc software development project using a Platform as a Service (PaaS) offering cloud.

A private cloud is the obvious choice when

- Private cloud has been adopted by industries when security is something of primary concern such as finance and health care which have some of the most rigorous compliance requirements. Your business is your data and your applications. Therefore, control and security are paramount.
- Your business is part of an industry that must conform to strict security and data privacy issues.
- Your company is large enough to run a next generation cloud data center efficiently and effectively on its own.

A hybrid environment is best choice when.

- Your company wants to use a SaaS application but is concerned about security. Your SaaS vendor can create a private cloud just for your company inside their firewall. They provide you with a virtual private network (VPN) for additional security.
- Your company offers services that are tailored for different vertical markets. You can use a public cloud to interact with the clients but keep their data secured within a private cloud.
- The management requirements of cloud computing become much more complex when you need to manage private, public, and traditional data centers all together. You'll need to add capabilities for federating these environments.
- Using the private cloud for mission-critical applications and using public clouds for non-critical applications. A firm, for example, may use a private cloud for production deployment and a public cloud for test and development of lower-tier applications.
- Another example is non-destructive Disaster Recovery (DR) testing. Organizations can test if their production environment is DR-ready by tapping the public clouds without any disruption.

V. CONCLUSION

Public, private and hybrid clouds each of them have their own distinct characteristics, pros and cons. We can't specifically suggest choosing only one particular cloud computing deployment model for an organization. The decision is taken by considering various influencing factors such as the requirements of an organization, type of the organization and the scale of the organization.

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