

2.1 What is a cloud computing?

Cloud computing gets its name as the metaphor for the Internet. Cloud computing is a general term for delivering hosted services over the internet to remotely store, process and share digital data.[3]

The National Institute of Standards and Technology (NIST) provide the following definition for cloud computing:

“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.”[6]

Users interact with cloud computing environments with the services that the cloud environment provides. The following examples of services are provided by a cloud (cloud services):

- Virtual servers
- Database services
- E-mail applications
- Storage

A company can use cloud services that are provided by third parties, or the company can build its own cloud and provide services from the cloud to internal company users, to selected business partners or customers, or to the world at large. [6]

For a service to be considered a “cloud service,” it needs to exhibit the following characteristics:

- Support self-service provisioning.
- Be accessible through the Internet or corporate intranet.
- Provide resources from a resource pool, without the user needing knowledge of the pool.
- Provide simple and fast resource elasticity, as users demand changes.
- Support a metering capability, which enables a dynamic chargeback model [6].

To provide these characteristics, the infrastructure that enables the cloud services takes advantage of two key enablers [6]:

_ Virtualization

Virtualization allows computing resources to be pooled and allocated on demand. It also enables pay-per-use billing to be implemented.

_ Automation

Automation allows for the elastic use of available resources, and for workloads to be moved to where resources are available. It also supports provisioning and de provisioning of service instances to support scalability.

Although these enablers are not part of any formal cloud definition, they are proven to be indispensable in delivering the essential cloud service characteristics.

Many traditional IT services are provisioned with the characteristics of a cloud service. So, how to provide a cloud service, or when to use a cloud service?

Knowing who are providing a cloud service when the service exhibits the characteristics listed previously, and it is provisioned by using the virtualization and automation enablers.

As the user of any service, whether it is being provisioned as a cloud service might be immaterial. However, the likely to use a cloud service when the service that using exhibits the characteristics listed previously. From a cloud user perspective, it is important be able to perform self-service activities that relate to the cloud service that used, to quickly provision new service instances, and have resources elastically sized to meet the changing processing demands [6].

2.2 Cloud Service Models

When discussing cloud services (identified in 2.1, “Cloud computing definition”), a helpful approach is to organize service capabilities into groups. NIST formally describes a standard for grouping cloud services, referring to them as *service models*. These service models are sometimes referred to as *delivery models*, because they describe the services that are delivered by the cloud model. The following sections describe the NIST service models. [6]

2.2.1 Infrastructure as a service (IaaS)

The IaaS model is the simplest for cloud service providers to provision. It may include the following elements:

- _ Processing
- _ Storage
- _ Network

Each of these elements is provisioned in an elastic fashion. As an IaaS user, you can deploy and run your chosen software, including operating systems and applications. You do not need to manage or control the underlying cloud infrastructure, but you have control over operating systems, storage, and deployed applications. You might also have limited control of select networking components (for example, host firewalls). Examples of commercial implementations of IaaS IBM SmartCloud managed backup, Amazon Elastic Compute Cloud (EC2). [6]

2.2.2 Platform as a service (PaaS)

The PaaS model includes services that build on IaaS services. They add value to the IaaS services by providing a platform in which the cloud users can provision their own applications, or conduct application development activities. The user does not manage the underlying cloud infrastructure (network, storage, operating systems), but may control configuration of the provisioned platform services. The following examples are of services that are provisioned in PaaS models:

- _ Middleware
- _ Application servers
- _ Database servers
- _ Portal servers
- _ Development runtime environments

Examples of commercial implementations of PaaS environments include IBM SmartCloud Application Services, Amazon Relational Database Service, and Microsoft Windows Azure. [6]

2.2.3 Software as a service (SaaS)

The SaaS model provides software services that are complete applications that are ready to use. The cloud user simply connects to the application, which is running at a remote location; the user might not know where. The cloud service provider is responsible for managing the cloud infrastructure, the platform on which the application is running, and the application itself. This approach eliminates the need for the users to install and run the application on their own computers, thereby significantly reducing the need for maintenance and support. [6]

SaaS is sometimes referred to as applications as a service because SaaS essentially provides applications as a service, rather than simply software in general. SaaS also

includes content services (for example video on demand) and higher value network services (for example VoIP) as typically encountered in communication service provider scenarios. Examples of commercial implementations of SaaS environments include IBM Payment Systems, IBM SmartCloud for Social Business, PeopleSoft HR, and Google Apps for Business. [6]

2.2.4 Business process as a service (BPaaS)

Unlike the previously defined service models, NIST does not provide a definition for BPaaS. In recognition of the IT industry direction of provisioning business processes as a service from within a cloud environment, IBM developed a definition of the BPaaS model. [6]

The BPaaS model combines software and workflow elements to deliver end-to-end business processes as a service. Many business processes have the potential to be delivered through this model [6] : both horizontal applications (it's any software application that is designed to be used by many different types of users and businesses, and it's a type of generic application that has usability and utility within a broad range of users [7]), such as payroll, technical support, and billing) and vertical markets (it's software that is defined and built according to a user's specific requirements in order to achieve specific functions and processes that are unique to that user [7] , such as health care and insurance). BPaaS allows businesses to pass on some of their day-to-day operating costs to service providers using a fee-for-service model, so that the businesses can focus on their core competencies [6].

Examples of commercial implementations of BPaaS include IBM Blueworks Live™, IBM Collaborative Care Solution for the health care market, and Google AdSense.[6]

2.2.5 Cloud service model layering

Figure 1-1 illustrates the way in which the service models described previously can be layered. It also contrasts the level of effort required of the service provider with that of the service user through the service model layers. As to travel up the service model layers, the service provider is responsible for providing more effort, as the level of functionality increases. By contrast, as to travel down the service layers, the service user must provide more effort in terms of environment customization. [6]

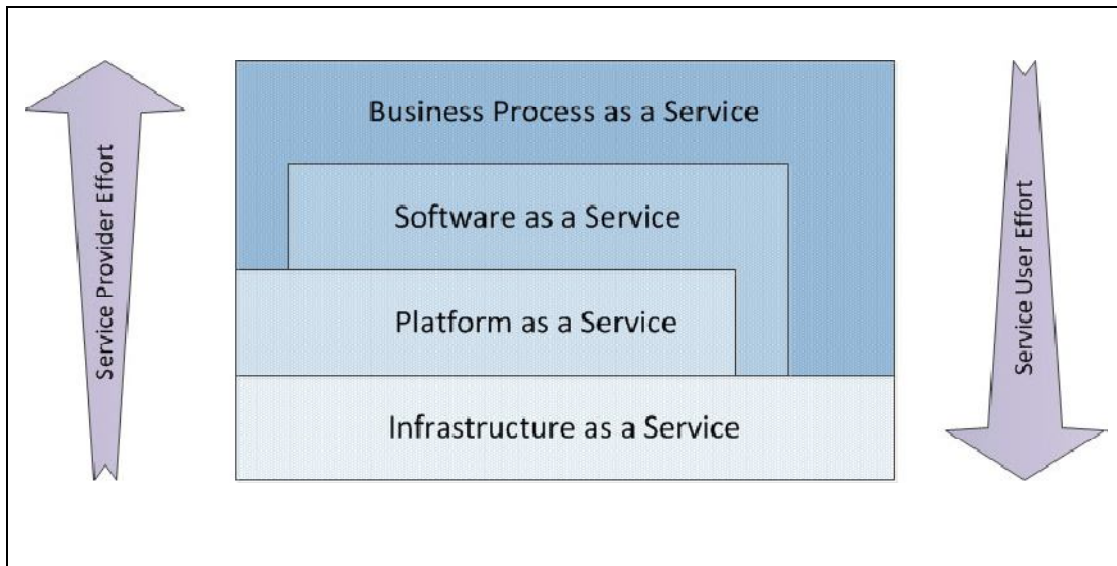


Figure 2-1 Cloud service model layering [6]

Table 1-1 lists the functions that are provided by the cloud service provider and the cloud service user for each service model. For any given service model, the service provider also provides the functions listed in the service models below it, whereas the cloud user provides the functions listed in the service models above it.[6]

Table 1-1 Cloud service provider and service user responsibilities by service model [6]

Service model	Cloud service provider delivered functions	Cloud user delivered functions
Business process as a service	Business Process	Business Process configuration
Software as a service	Applications	Application configuration
Platform as a service	Languages Libraries Tools Middleware Application Servers Database Servers	Applications
Infrastructure as a service	Processing Storage Network	Languages Libraries Tools Middleware Application servers Database servers

2.3 Cloud delivery models

Cloud delivery models refer to how a cloud solution is used by an organization, where the data is located, and who operates the cloud solution. Cloud computing supports multiple delivery models that can deliver the capabilities needed in a cloud solution.

The cloud delivery models are as follows:

- _ Public cloud
- _ Private cloud
- _ Hybrid cloud
- _ Community cloud

These delivery models provide services in line with the service models described in 2.2, “Cloud service models”. Integrating them with existing IT systems and with other clouds is possible. Figure 2-2 illustrates these cloud delivery models, and identifies some of their characteristics in terms of roles, users, and accessibility. [6]

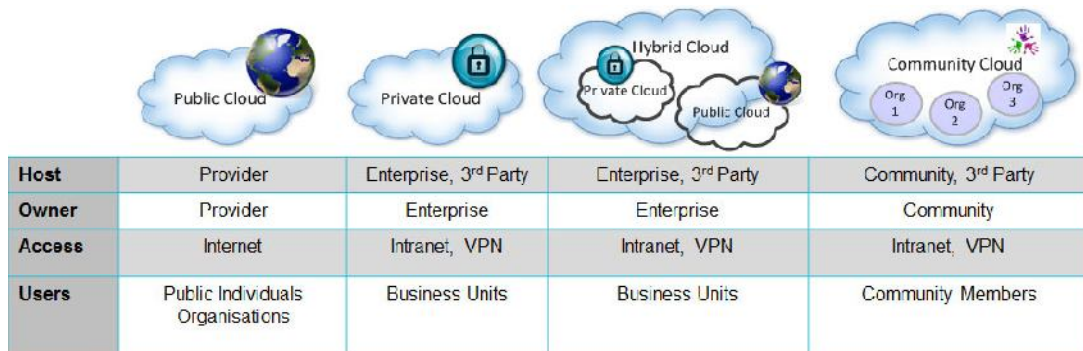


Figure 2-2 Cloud delivery models [6]

2.3.1 Public clouds

A public cloud is one in which the cloud infrastructure is made available to the general public or a large industry group over the Internet. The infrastructure is not owned by the user, but by an organization providing cloud services. Services can be provided either at no cost, as a subscription, or under a pay-as-you-go model.

Examples of public clouds include IBM SmartCloud Enterprise, Amazon Elastic Compute Cloud (EC2), Google AppEngine and Windows Azure Services Platform.

[6]

2.3.2 Private clouds

A private cloud refers to a cloud solution where the infrastructure is provisioned for the exclusive use of a single organization. The organization often acts as a cloud service provider to internal business units that obtain all the benefits of a cloud without having to provision their own infrastructure. By consolidating and centralizing services into a cloud, the organization benefits from centralized service management and economies of scale. [6]

A private cloud provides an organization with some advantages over a public cloud. The organization gains greater control over the various resources that make up the cloud. In addition, private clouds are ideal when the type of work being done is not practical for a public cloud because of network latency, security, or regulatory concerns. [6]

A private cloud may be owned, managed, and operated by the organization, a third party, or a combination. The private cloud infrastructure is usually provisioned on the organization's premises, but it may also be hosted in a data center that is owned by a third party. [6]

2.3.3 Hybrid clouds

A hybrid cloud, as the name implies, is a combination of various cloud types (public, private, or community; see 2.3.4, "Community clouds"). Each cloud in the hybrid mix remains a unique entity, but is bound to the mix by technology that enables data and application portability [6].

The hybrid approach allows a business to take advantage of the scalability and cost-effectiveness of a public cloud without exposing applications and data beyond the corporate intranet. A well constructed hybrid cloud can service secure, mission-critical processes, such as receiving customer payments (a private cloud service), and also those that are secondary to the business, such as employee payroll processing (a public cloud service). [6]

The major drawback to a hybrid cloud is the difficulty in effectively creating and governing such a solution. Services from a variety of sources must be obtained and

provisioned as though they originated from a single location, and interactions between private and public components make the implementation even more complicated. [6]

2.3.4 Community clouds

A community cloud shares the cloud infrastructure across several organizations in support of a specific community that has common concerns (for example, mission, security requirements, policy and compliance considerations). The primary goal of a community cloud is to have participating organizations realize the benefits of a public cloud, such as shared infrastructure costs and a pay-as-you-go billing structure, with the added level of privacy, security and policy compliance usually associated with a private cloud.[6]

The community cloud infrastructure may be provided on-premises or at a third party's data center, and may be managed by the participating organizations or a third party. [6]

2.4 Cloud service roles

The IBM CCRA defines the following interrelated roles:

- _ Cloud Service Creator
- _ Cloud Service Provider
- _ Cloud Service Consumer

These roles are interrelated in that a Cloud Service Creator is responsible for creating a cloud service, which can be run by a Cloud Service Provider, and exposed to Cloud Service Consumers. Multiple roles may be fulfilled by the same organization or person [6].

2.4.1 Cloud Service Creator

The Cloud Service Creator is responsible for creating a cloud service. The creator may be an individual or an organization that designs, implements, and maintains runtime and management artifacts that are specific to a cloud service. Typically, Cloud Service Creators build their cloud services by using functionality that is exposed by a Cloud Service Provider [6].

Also typical is that the operations staffs, which are responsible for operating a cloud service, are closely integrated with the development organization that develops the service (this integration is commonly referred to as *DevOps*). This close integration

helps to achieve the delivery efficiency that is expected from cloud services, because it allows a short feedback loop to implement changes in the cloud service. [6]

2.4.2 Cloud Service Provider

The Cloud Service Provider has the responsibility of providing cloud services to Cloud Service Consumers. The provider sets up the cloud service, and manages the effective running of the service, which can include the following tasks (and others):

- _ Determine performance services level and management strategies.
- _ Monitor performance of virtualization infrastructure and service level agreements (SLAs).
- _ Manage long term capacity and performance trends.
- _ Analyze how to prevent costly service quality problems.
- _ Ensure alignment of business and operational support systems.
- _ Track performance against the provider business plan.

A Cloud Service Provider might be a link within a chain of service providers and service consumers, with each provider adding some value to the service within the chain. In this case, each service provider needs to establish a partnership with their service provider, to be able to guarantee service levels to their clients. [6]

2.4.3 Cloud Service Consumer

A Cloud Service Consumer is the user of a cloud service. The consumer might be an organization, a human being, or an IT system that requests, uses, and manages instances of a cloud service. Managing a service can include performing activities such as changing quotas for users, changing CPU capacity assigned to a virtual machine (VM), or increasing maximum number of seats for a web conference. The service consumer may be billed for all (or a subset) of its interactions with the cloud service and the provisioned service instances. [6]

Within the Cloud Service Consumer role, more specific roles might exist. The consumer organization might require a technical role responsible for making service consumption work from a technical perspective. There might also be a business person on the consumer side who is responsible for the financial aspects of consuming the service. In simple public cloud scenarios, all of these consumer roles could be collapsed into a single person. [6]

The Cloud Service Consumer browses the service offering catalog and triggers service instantiation and management from there. There might be cases where the interaction with the service delivery catalog is tightly embedded within the actual cloud service. In particular these cases are common for SaaS and BPaaS cloud services where application-level virtualization is implemented. [6]

2.5 Benefits of cloud

Using cloud is an economical option for both businesses and individuals. It can provide low cost access to a number of useful programs and almost unlimited storage space [8].

The benefits of cloud are wide-ranging and reach different sectors of the market in different ways, they include [4]:

- Increased productivity by allowing businesses to focus on their core competencies and customer offerings rather than IT infrastructure and maintenance,
- Economies of scale through use of data centers that are more energy efficient and environmentally sustainable,
- Reduced operating and capital cost,
- Greater speed to market by reducing solution deployment time by leveraging cloud infrastructure,
- Dynamic increased capacity and the ability to cater to business peaks without investing in infrastructure,
- Transformation of organizations fixed cost into variable cost,
- Up-to-date software, professionally managed,
- Improved security through centralization where cloud vendor is reliable and less expertise existed in company/individual,
- New business opportunities and new markets by offering high computing power at lower cost,
- Faster and cheaper innovation by providing an existing platform for developers to build on,
- Leverage on cloud computing for reliable and scalable backup and recovery facilities for Disaster Recovery (DR), and
- Low barrier to entry, which can foster innovation and entrepreneurship.

2.6 Cons of cloud computing

There are a number of conditions and risks associated with cloud that potential users may want to consider [8].

- It requires a fast, continual Internet connection
- The connection can be slow if many users are accessing the server
- Information may not be secure
- Programs on the server may not be the full version.