Course: Cloud Computing

Week 2: Cloud Service Models

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Lecture learning outcome:

- At the end of the lecture you will be able to;
- Explain the different cloud computing services like Software as a service, Infrastructure as a service, Platform as a service.
- Understand other subsections of Cloud services like Naas, Staas, Dtaas, Dbaas, Taas, SECaas among others
- Understand deployment of the different services on various clouds like Public cloud, Private cloud, Hybrid, Community cloud.

1.1 Over view of Cloud Computing Services

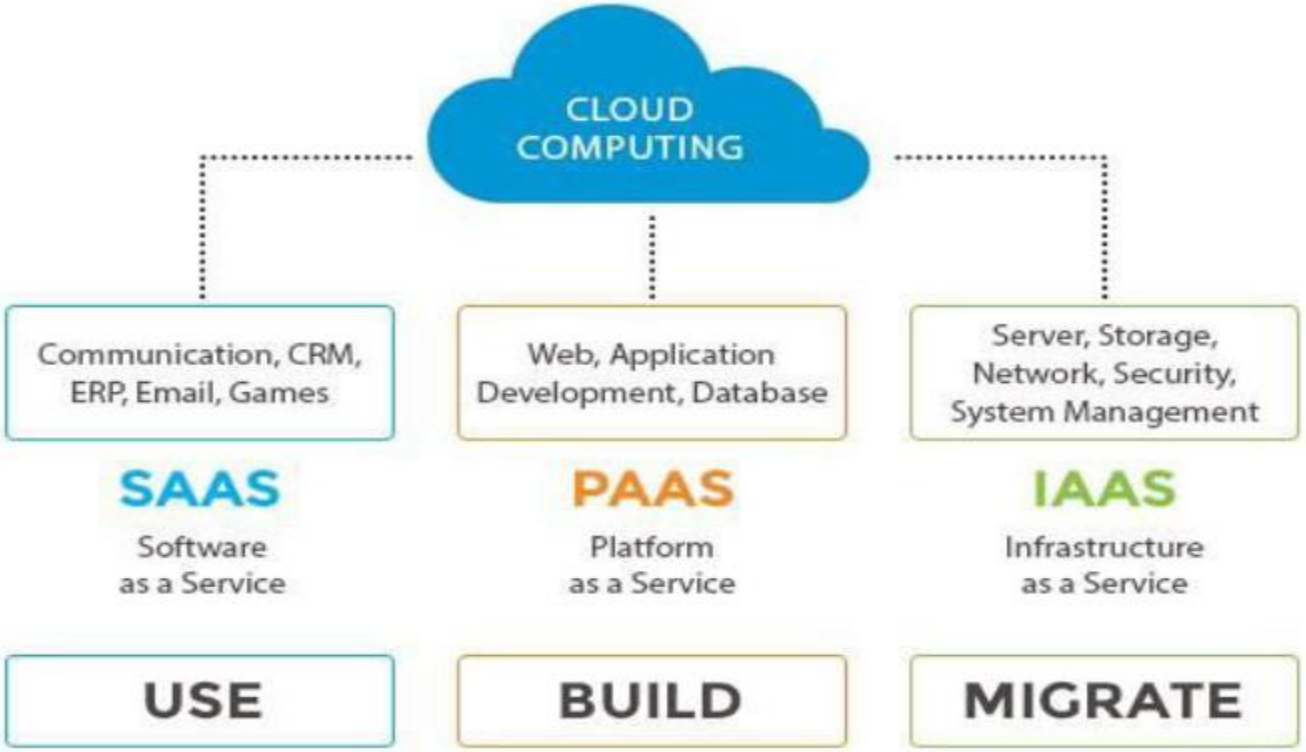
National Institute of Standards and Technology (NIST) outlines three service layers to extend cloud computing capabilities: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS)

- **Software-as-a-service (SaaS):** Provides approved applications for customers to use. Licenses are granted on a pay-as-you-go or on-request basis. SaaS applications include Big Commerce, Google Apps, Salesforce, Dropbox, Mail Chimp, Zen Desk, DocuSign, Slack, and Hub spot, to name a few.

Cloud Computing Services

- **Infrastructure-as-a-service (IaaS):** Delivers network services, servers, storage facilities, frameworks as part of an on-demand service. IaaS providers include Digital Ocean, Linode, Rackspace, Amazon Web Services (AWS), Cisco Meta pod, Microsoft Azure, and Google Compute Engine (GCE).
- **Platform-as-a-service (PaaS):** it is a platform for creating programming that is delivered over the Internet. Platforms like Salesforce.com and Heroku are used in this model.

Cloud Computing Services



- (Singh, 2021)

Platform as a service (PaaS)

- Is a Cloud computing model where cloud providers extend software and hardware tools for application development, reducing on how much a developer needs to install in house software and hardware, a user simply deploys their code on an available platform and runs it.

Platform as a service (PaaS)

PAAS incorporates various Infrastructure components from the vendor like operating system, servers, databases, middleware, networking equipment, frameworks, preconfigured capabilities like programming languages, storage facilities, drivers, security mechanisms, backup systems all configured and managed by the cloud provider, on the other hand the user or business provides the necessary data and applications making it affordable for many projects.

On premise platform

On premise platform: Business buy their own operating systems, servers, databases, middleware, networking equipment's, storage facilities, drivers, install antiviruses and other security mechanisms to create a good application development environment.

Table: Platform as a service cloud providers (Bajaj, 2020)

Considerations	Cloud Foundry	AWS Elastic	Heroku	Google App Engine	On shift online	Appfog
Programming Languages	Go Groovy Ruby Scala Java Node PHP Python	Node PHP Python Ruby .Net Go Java	Java Node PHP Python Clojure Go Groovy Ruby Scala	PHP Python Ruby Go Java Node	.Net Java PHP Python Node Perl Ruby	Java Node PHP Python Ruby

Considerations	Cloud Foundry	AWS Elastic	Heroku	Google App Engine	On shift online	Appfog
Deployment models	Private	Public	Public & Private	Public	Public, Private	Public, Private
Runtime Environment	Apache Tomcat	Apache Tomcat Phusion Passenger Pumawebserver for Ruby Microsoft IIS Nginx	Dyno Runtime	Jetty	Apache Tomcat	Gunicorn-WSGI server, Apache Tomcat

Databases	MySQL, Redis, MongoDB	Amazon RDS Amazon SimpleDB Microsoft SQL Server, Oracle	PostgreSQL MongoDB Cloudant and Redis	BigTa ble Cloud SQL	MySQL SQLite PostgreSQ L MongoDB	Mongodb MySQL PostgreSQL Redis
Pricing Model	Free usage	Pay per use monthly bills free usage	Pay per use monthly bills free usage	Pay per use monthly billing free usage	Hybrid usage, monthly billing or fixed usage, free usage	Fixed usage, monthly billing

Benefits

- Affordable for projects since they do not have to invest in IT Infrastructure to create on-site programing development environments.
- Reduces on the cost of management and maintenance

Benefits

- Different kinds of application development services and application execution services are employed to facilitate the development, deployment, hosting, and testing of applications within an integrated environment, making it Simple and convenient for users.

Infrastructure as a Service (IaaS):

- Infrastructure as a Service supports in hosting services like network access, routing services, hardware, administrative services needed to store applications and a platform for running applications. Scaling of bandwidth, memory and storage are generally included. The service provider owns the devices and is responsible for housing, running and maintaining them.

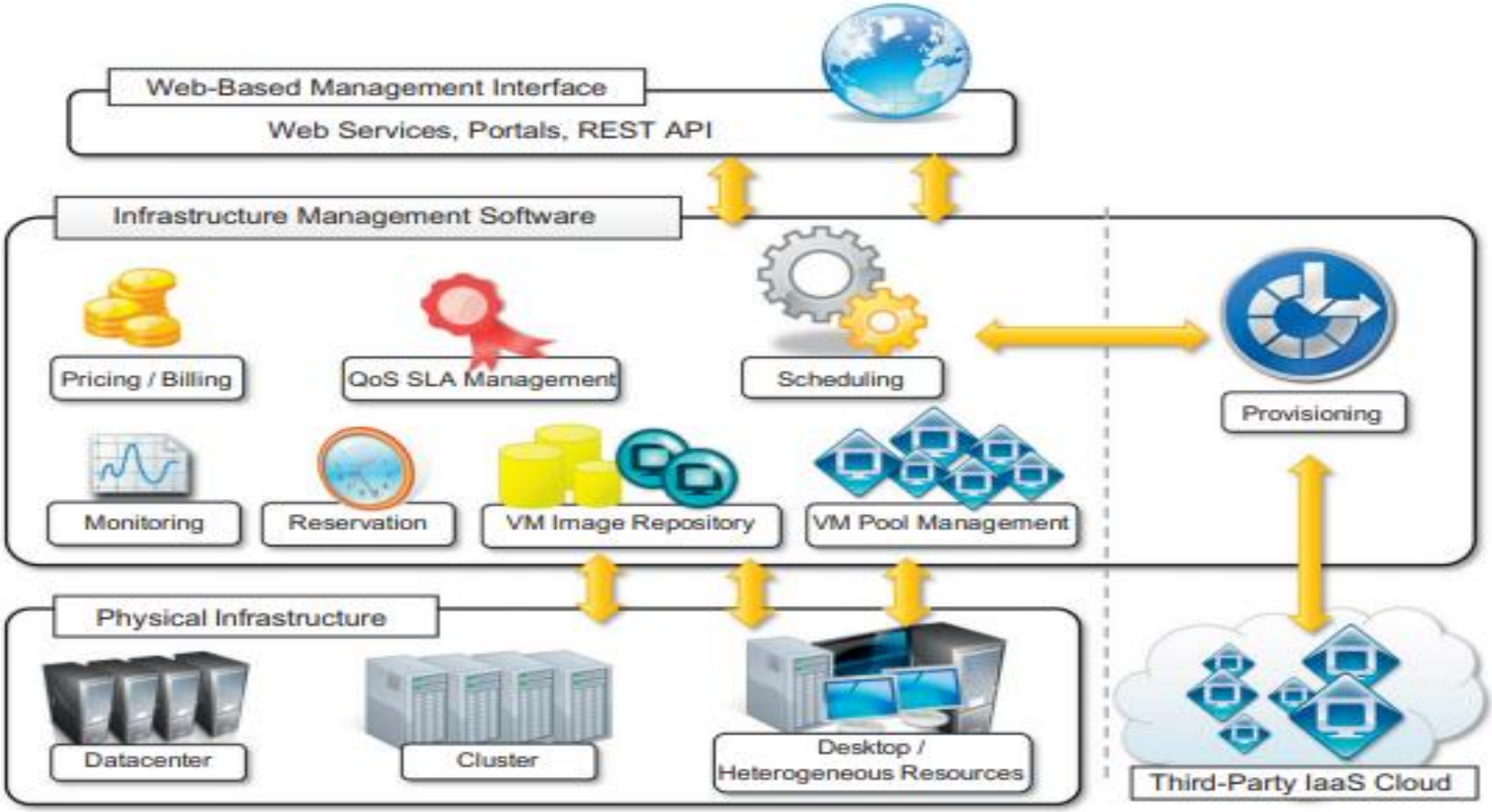
Infrastructure as a Service (IaaS):

- This allows users to maximize the utilization of computing capacities without having to own and manage their own resources; the users can scale up and down the resources according to their present needs without incurring capital expenditures on these resources that are often underutilized

Infrastructure as a Service (IaaS):

- IaaS providers (e.g., Amazon EC2, Windows Azure Virtual Machines, Google Compute Engine) the service providers host computers as Virtual Machines that are managed by low-level codes called hypervisors such as Xen or KVM to meet users' computing needs

Infrastructure-as-a-Service reference implementation.



- (Buyya, 2013)

Infrastructure-as-a-Service reference implementation

- Web services, RESTful APIs, and mash-ups- enable applications or users to access the services exposed by the underlying infrastructure.

- Scheduler-allocates execution of virtual machine instances.

Infrastructure-as-a-Service reference implementation

- The pricing and billing component takes care of the cost of executing each virtual machine instance and maintains data that will be used to charge the user.
- The monitoring component tracks the execution of each virtual machine instance and maintains data required for reporting and analyzing the performance of the system.

Infrastructure-as-a-Service reference implementation

- The reservation component stores the information of all the virtual machine instances that have been executed or that will be executed in the future.
- QoS/SLA(Quality of Service) management component will maintain a repository of all the SLAs made with the users; ensures that a given virtual machine instance is executed with the desired quality of service.

Infrastructure-as-a-Service reference implementation

- The VM repository component provides a catalog of virtual machine images that users can use to create virtual instances. Some implementations also allow users to upload their specific virtual machine images.
- A VM pool manager component is responsible for keeping track of all the live instances.

Characteristics and components of IaaS:

- Utility computing service and billing model.
- Automation of administrative tasks.
- Dynamic scaling.
- Desktop virtualization.
- Policy-based services.
- Internet connectivity.

Software-as-a-Service (SaaS)

- “In the software as a service model, the application, or service, is deployed from a centralized datacenter across a network—Internet, Intranet, LAN, or VPN—providing access and use on a recurring fee basis. Users “rent,” “subscribe to,” or “are assigned,” or “are granted access to” the applications from a central provider” (Buyya, 2013).

Software as a service Software-as-a-Service (SaaS)

Extends access to applications through the Internet as a Web-based service saving clients from the need to neither install anything on their premises nor have to pay considerable up-front costs to purchase the software and the required licenses.

Applications are shared across multiple users in SaaS applications like Customer Relation Management and Enterprise Relation Applications (ERPs) that take care of common needs across different Enterprises.

Types of Saas

- Business Utility SaaS-Sales force automation applications are used by businesses and individuals for managing and collecting data. Customer Relationship Management (CRM), Human Resources and Accounting are the popular use cases.
- Social Networking SaaS - Applications are used by individuals for networking and sharing information, photos, videos, etc. like Facebook.

Characteristics of saas

- The product sold to customer is an application access.
- The application is centrally managed.
- The service delivered is one-to-many.
- The service delivered is an integrated solution delivered on the contract, which means provided as promised.

Pros and Cons of Saas

PROS

- Easy to use: Most of the SaaS applications have friendly user interface and it only necessitates having internet and a web browser to utilize them
- Cheap: SaaS services are affordable and work with a pay as you go pricing model.

PROS

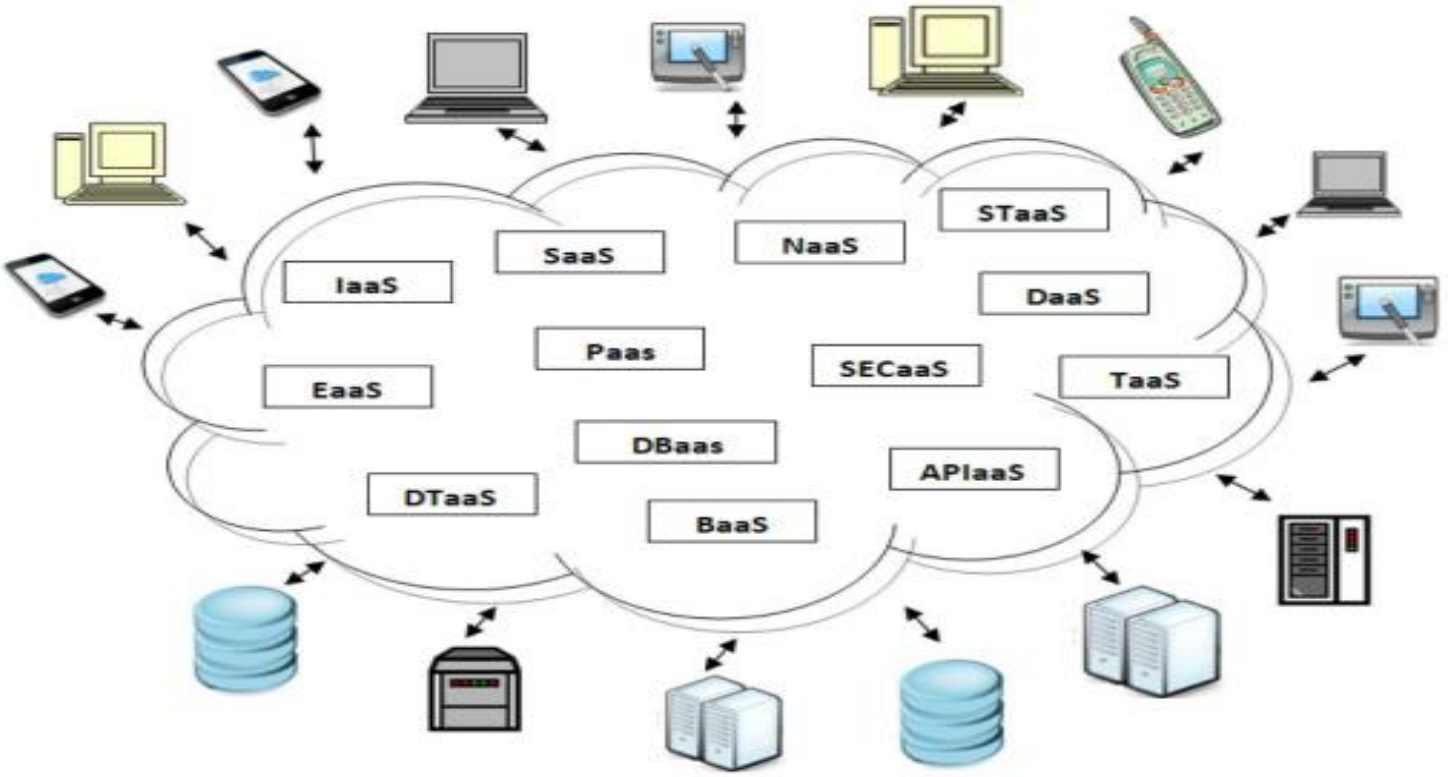
- Scalability: Since customers do not have to worry about scaling up or down, with up scaling the service providers provides the necessary infrastructure, with scaling down, the user only pays for what he needs.
- Facilitate data sharing and collaboration since data is stored in a central location.

cons

CONS

- Robustness: due to browser limitations Saas Application functionalities may be limited than traditional software for example Google Doc verse Microsoft Office (offline Word provided more advanced formatting options).
- Privacy: user data is very vulnerable to attack since it may be accessible to many users
- Reliability: in an event of failure from the providers end, many clients will be greatly affected

An overview of cloud computing service



- (Lee, 2014)

Other Services (Lee, 2014).

- ***Network as a Service (NaaS)*:**

Network as a Service (NaaS), part of IaaS, provides users with needed data communication capacity to accommodate data traffic during activities such as video conferencing or large file downloads. NaaS providers (e.g., Verizon, AT&T) operate using three common service models: virtual private network (VPN), bandwidth on demand (BoD), and mobile virtual network (MVN).

- ***Storage as a Service (STaaS):***

Storage as a Service (STaaS), a form of IaaS, provides storage infrastructure, synchronize data across multiple devises, manage offsite backups, mitigate risks, and preserve data. STaaS providers (e.g., Amazon Simple Storage Service, IBM Tivoli Storage Manager).

- ***Desktop as a Service (DTaaS):***

Another widely-used instance of an infrastructural service is Desktop as a Service

- ***Database as a Service (DBaaS):***

Database as a Service (DBaaS), related to IaaS, Enables users to create, store, and access databases at a host site on demand, the provider manages the entire database including backup, administration, restoration, reorganization, and migration. Cloud-based database systems such as Google BigTable, Amazon Simple DB, and Apache HBase allow users to submit queries to databases.

- ***Backend as a Service (BaaS):***

Backend as a Service (BaaS), a type of IaaS, provides web and mobile app developers a way to connect their applications to backend cloud storage with added services such as user management, push notifications, social network services integration using custom software development kits and application programming interfaces

- ***Testing as a Service (TaaS)*:**

Testing as a Service (TaaS), provides users with software testing capabilities such as generation of test data, generation of test cases, execution of test cases, and test result evaluation on a pay-per-use basis

- ***Email as a Service (EaaS)*:**

Email as a Service (EaaS), an instance of SaaS, provides users with an integrated system of emailing, office automation, records management, migration, and integration services with archiving, spam blocking, malware protection, and compliance

- **Data as a Service (DaaS):**

Data as a Service (DaaS) provides data on demand to a diverse set of users, systems, or applications. Leading DaaS providers such as Data Direct offer software to connect business applications to data whereby data connectivity for distributed systems is simplified and streamlined. Data encryption and operating system authentication are commonly provided for added security.

- **Security as a Service (SECaaS):**
- Security as a Service (SECaaS) is a new approach to security in which cloud security is moved into the cloud itself whereby cloud service users will be protected from within the cloud using a unified approach to threats. Four mechanisms of cloud security are currently provided: email filtering, web content filtering, vulnerability management, and identity management

CLOUDS TYPES

Public/Internet Clouds

*Third-party, multitenant cloud infrastructure and services

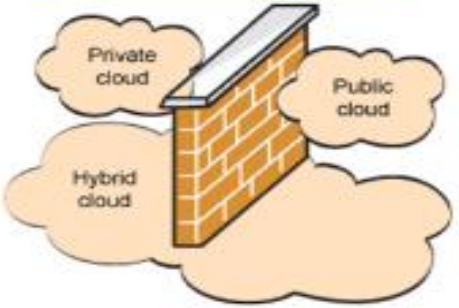
*Available on a subscription basis to all

Private/Enterprise Clouds

*A public cloud model within a company's own datacenter/infrastructure for internal and/or partners' use

Hybrid/Inter Clouds

* Mixed use of private and public clouds; leasing public cloud services when private cloud capacity is insufficient



- Source: Buyya, R. (2013). Mastering Cloud Computing

Cloud Types

- The different services that are provided to customers are implemented on top of a cloud infrastructure
- Types of clouds
- • Public clouds. The cloud is open to the wider public.
- • Private clouds. The cloud is implemented within the private premises of an institution and generally made accessible to the members of the institution or a subset of them.

Cloud types

- Hybrid or heterogeneous clouds. The Combination of the public and private cloud
- Community clouds. The cloud is characterized by a multi-administrative domain involving different deployment models (public, private, and hybrid), and it is specifically designed to address the needs of a specific industry

Public Cloud

- In the Public Cloud, services are broad casted to everyone, from anywhere, and at any time through the Internet. The public cloud is distributed system with one or more datacenters connected together, on top of which the specific services offered by the cloud are implemented.
- In the public cloud customer that are renting infrastructure or subscribing to application services, can easily upsize or downsize their IT according to the demands of their business. Currently, public clouds are used both to completely replace the IT infrastructure of enterprises and to extend it when it is required

Characteristics of Public Cloud

- A public cloud is meant to serve a multitude of users, not a single customer.
- They have the ability to scale on demand and sustain peak loads
- Can have one or more data centers geographically dispersed to share the load of users and from their different locations. For example,

Characteristics of Public Cloud

- Amazon Web Services has datacenters installed in the United States, Europe, Singapore, and Australia; they allow their customers to choose between three different regions: us-west-1, us-east-1, or eu-west-1.
- The regions can further be divided into zones that are mapped to the data center

Services offered over the public cloud

- A public cloud can offer any kind of service: infrastructure as a service, platform as a service, or software as a service, applications. For example, Amazon EC2 is a public cloud provider that provides infrastructure as a service; Google AppEngine deploys its services over a public cloud that providing application development platform as a service; and SalesForce.com is a public cloud that provides software as a service.

Limitations of Public clouds

1. Loss of Control;

- The cloud provider is in complete control of the infrastructure and eventually, of the customers' core logic and sensitive data.

2. Privacy issues: , institutions such as government and military agencies will not consider public clouds as an option for processing or storing their sensitive data, in case of a breach in the security infrastructure of the provider the sensitive data could be exposed to others.

Limitations of Public clouds

3. Different Regulations: the geographical location of a datacenter generally determines the regulations that are applied to management of digital information

Private cloud

- In private cloud resources are accessed within the boundaries of an organization
- Private clouds are virtual distributed systems that rely on a private infrastructure and provide internal users with dynamic provisioning of computing resources. Instead of a pay-as-you-go model, private cloud use different mechanisms like billing the different departments or sections of an enterprise.

Benefits

1. They keep the core business operations in-house by relying on the existing IT infrastructure and reducing the burden of maintaining it once the cloud has been set up.
2. Existing IT resources can be better utilized because the private cloud can provide services to a different range of users
3. Provide a possibility of testing applications and systems at a comparatively lower price before deploying them on the public virtual infrastructure

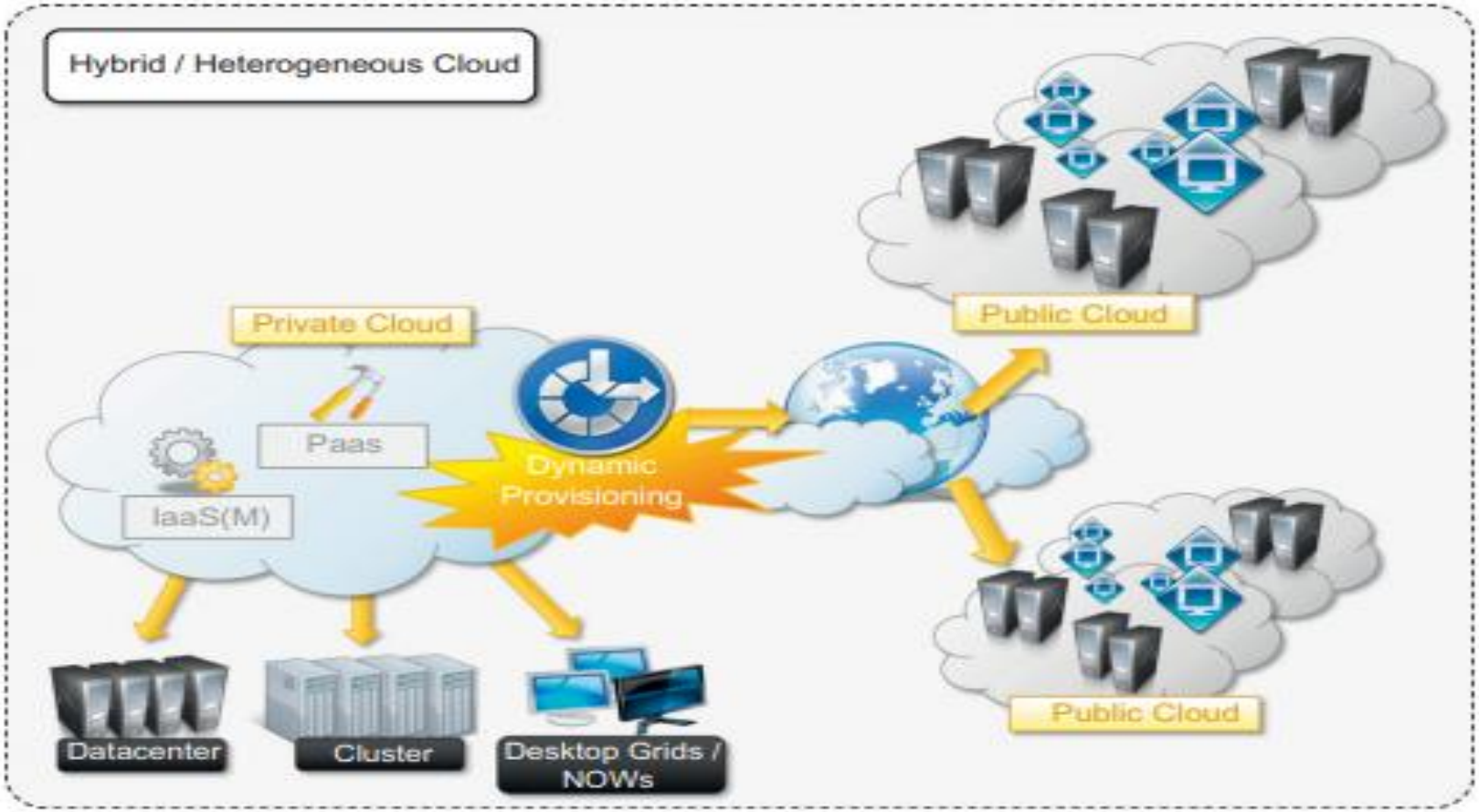
Benefits

3. Customer information protection: In-house security is easier to maintain and rely on.

4. Quality of service implies specific operations such as appropriate clustering and failover, data replication, system monitoring and maintenance, and disaster recovery, and other uptime services can be commensurate to the application needs.

5. Compliance with standard procedures and operations. If organizations are subject to third-party compliance standards, specific procedures have to be put in place when deploying and executing applications.

Hybrid cloud

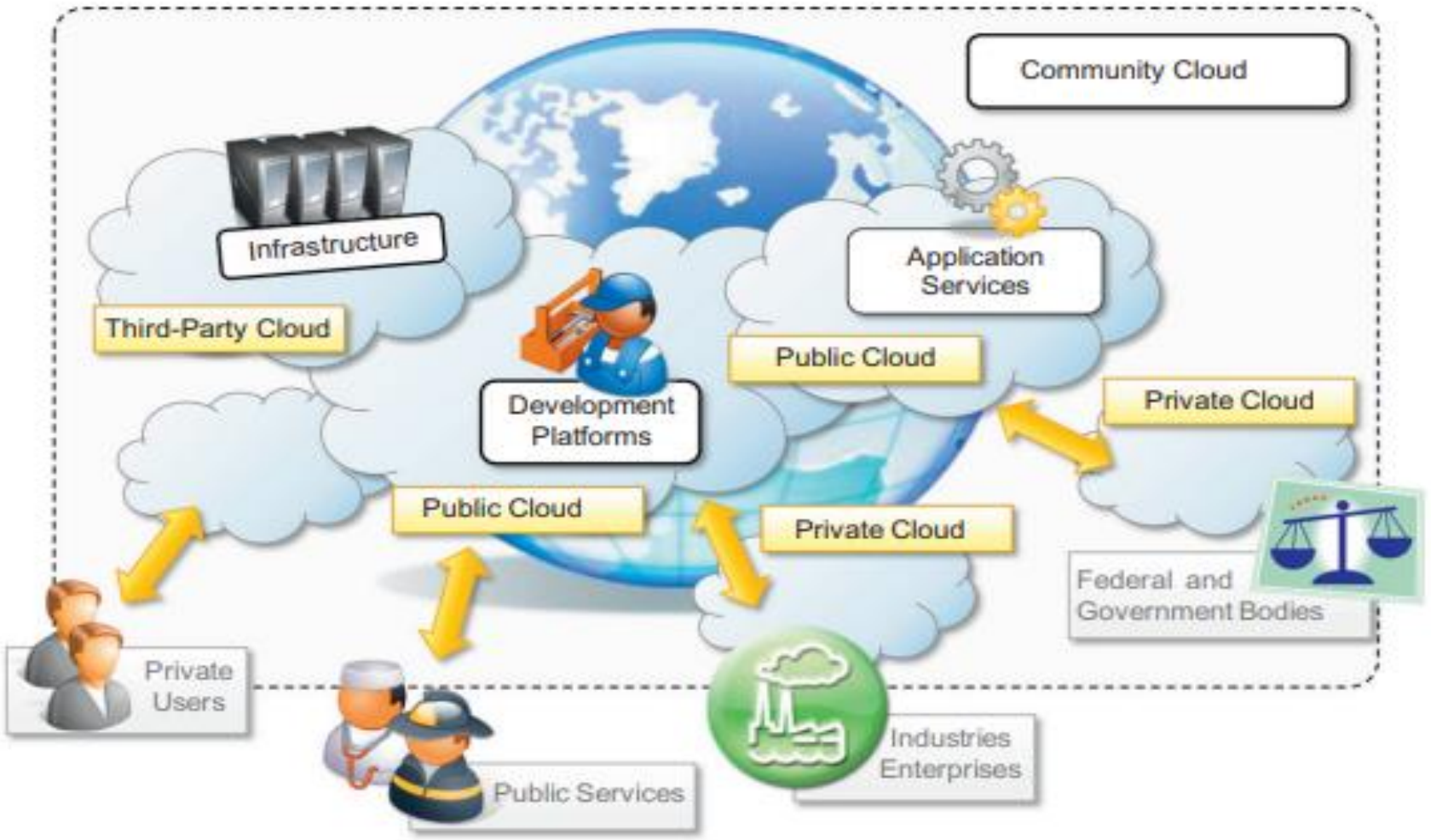


- (Buyya, 2013)

Hybrid clouds

- Combination of both Public and Private Clouds
- Allow enterprises to exploit existing IT infrastructures, maintain sensitive information within the premises, and naturally grow and shrink by provisioning external resources and releasing them when they're no longer needed.
- Hybrid clouds address scalability issues by leveraging external resources for exceeding capacity demand

Community Cloud



- (Buyya, 2013)

Community Cloud

- Community clouds are distributed systems created by integrating the services of different clouds to address the specific needs of an industry, a community, or a business sector.
- The infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on premise or off premise.
- Different organizations such as government bodies, private enterprises, research organizations, and even public virtual infrastructure providers contribute with their resources to build the cloud infrastructure.

Sectors for community clouds:

- Media industry. The creation of digital content involves movement of large data, massive compute-intensive rendering tasks, and complex workflow executions. Community clouds can provide a shared environment where services can facilitate business-to-business collaboration and offer the horsepower in terms of aggregate bandwidth, CPU, and storage required to efficiently support media production.

Sectors for community clouds:

- Healthcare industry. Community clouds can provide a global platform on which to share information and knowledge without revealing sensitive data maintained within the private infrastructure.
- Energy and other core industries. Industries involve different providers, vendors, and organizations, a community cloud can provide the right type of infrastructure to create an open and fair market.

Sectors for community clouds:

- Public sector. A community cloud can constitute the optimal venue to provide a distributed environment in which to create a communication platform for performing operations like business-to-administration, citizen-to-administration, and possibly business-to-business processes. Some examples include invoice approval, infrastructure planning, and public hearings.
- Scientific research.

Benefits:

- Openness. By removing the dependency on cloud vendors, community clouds are open systems in which fair competition between different solutions can happen.
- Community. Being based on a collective that provides resources and services, the infrastructure turns out to be more scalable because the system can grow simply by expanding its user base.

Benefits:

- Graceful failures. Since there is no single provider or vendor in control of the infrastructure, there is no single point of failure.
- Convenience and control. Within a community cloud there is no conflict between convenience and control because the cloud is shared and owned by the community, which makes all the decisions through a collective democratic process.

summary

- This lecture included understanding cloud services;
- **Software-as-a-service (SaaS):** Provides approved applications for customers to use.
- **Infrastructure-as-a-service (IaaS):** Delivers network services, servers, storage facilities, frameworks as part of an on-demand service.
- **Platform-as-a-service (PaaS):** it is a platform for creating programming that is delivered over the Internet
- **Others**
- Network as a service, Storage as a service, Data as a service, Testing as a service, Email as a service, Backend as a service.
- Cloud Types: Public cloud, Private cloud, Hybrid Cloud, Community Cloud.

Next Lecture

- The next lecture will cover;

Data storage in the cloud;

Reference

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