

# Cloud Computing Introduction and Foundations Concepts

Cloud NIST model, service types and deployment models

References:

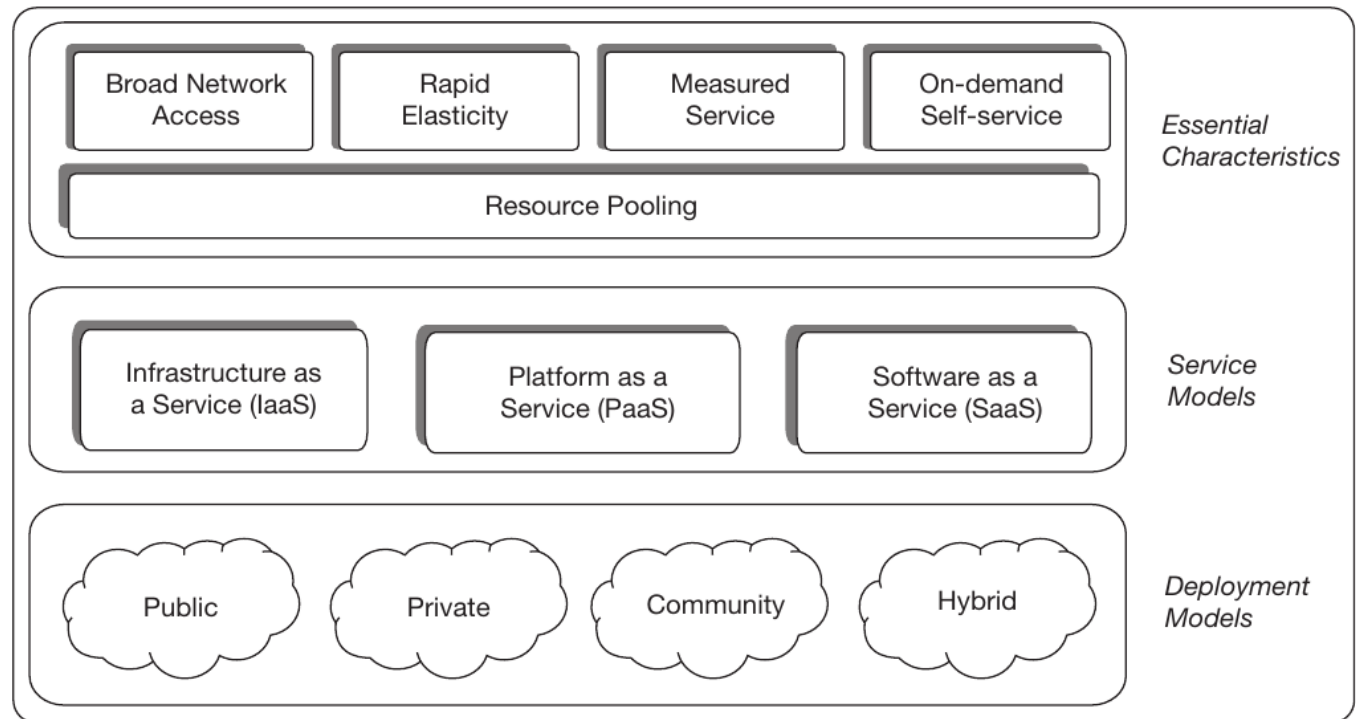
- [cam-san] Chapter 4, 5

# Cloud Computing Model

- Cloud computing standardization is limited, as the technology is still novel and recently introduced
- Every cloud provider adopts its technological solution for its services
- As any technology, we need at least a standard model for convenience of understanding
- In its early days several cloud computing models have been defined in order to standardize cloud computing aspects
- Among them, we have the model defined by the National Institute of Standards and Technology (NIST)
- The model published in 'NIST Cloud Computing Reference Architecture' is the most appreciated and accepted model
- It defines a model that provide a definition of cloud computing and a reference architecture that highlights all the components of a cloud system

# NIST Model

- The NIST model defines the basic aspects and characteristics of cloud computing:
  - **Essential characteristics:** *the set of mandatory features that each cloud computing system must have*
  - **Service Models:** *the set of different types of service that are provided to consumers*
  - **Deployment Models:** *the set of different models for the deployment of the cloud infrastructure*



# Essential characteristics

- The NIST model includes five essential characteristics for a cloud computing infrastructure : *Broad Network Access* (the infrastructure must be accessed from anywhere), *Rapid Elasticity* (resources are allocated/deallocated rapidly), *Measured Service* (the resources are measured and billed proportionally to the usage), *On-Demand* (resources are allocated upon request), *Resource Pooling*
- **Resource Pooling:** computing resource (processor, memory, storage and network) are installed and available on demand to consumers to satisfy their needs. The resource pools are maintained remotely and must be large enough to satisfy many users simultaneously. In traditional computing paradigm, resources each consumer possessed its own physical computing resources.

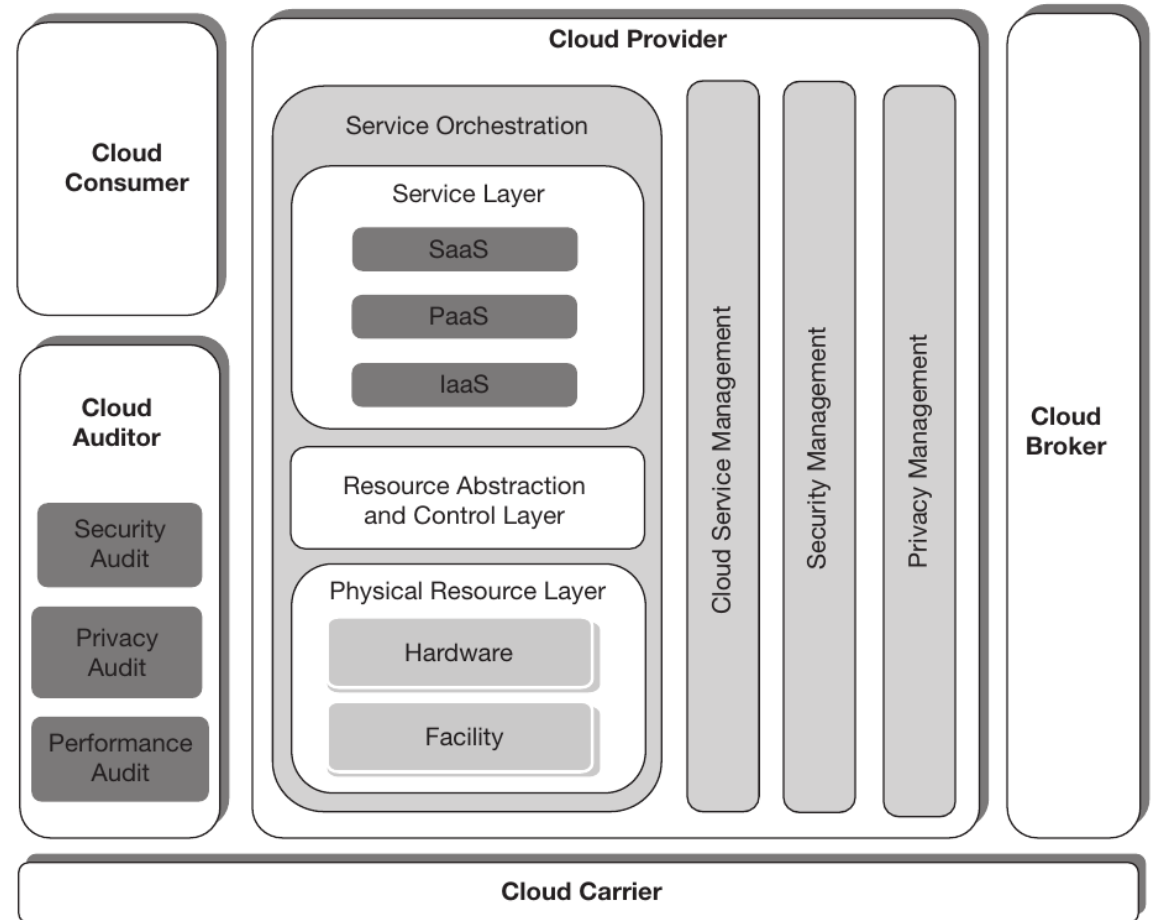
We already presented the essential characteristics,  
when introducing cloud computing!

# Service Delivery and Deployment

- **Service delivery models:** the NIST model defines three main category of service based on what kind of service it is offered to consumers and how the service is provided : Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS)
- **Deployment:** the NIST model defines four types of deployment, based on how the infrastructure is deployed: Public cloud, Private cloud, Community cloud and Hybrid clouds
- We will cover all of them in details in a bit

# NIST Reference Architecture

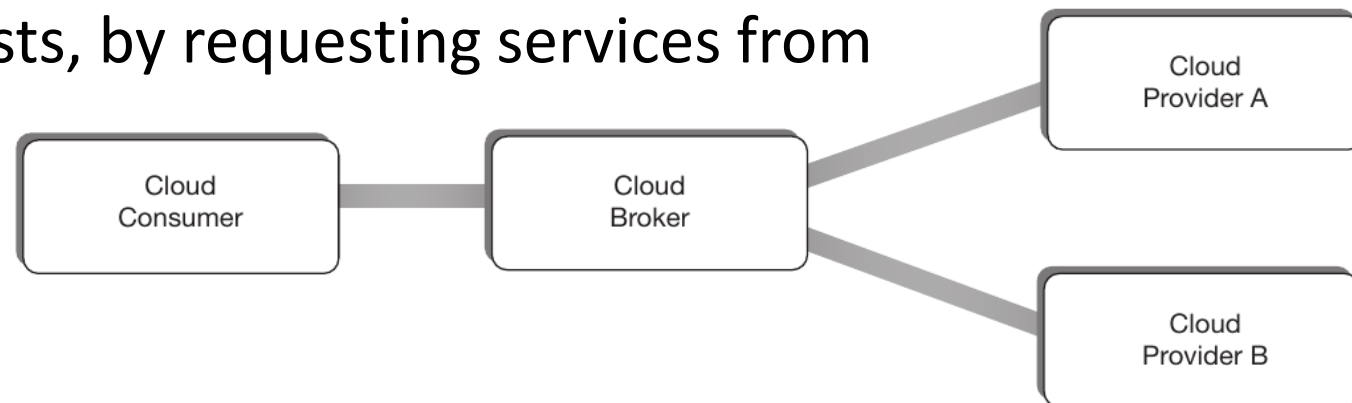
- The reference architecture defines the set of elements that compose the cloud ecosystem
- It focuses on what composes the cloud infrastructure and not how it is implemented
- It is general and neutral enough to cover all cloud implementations available in the market at the moment
- It specifies also the involved actors



# Actors

- Based on the model, the actors involved are: Cloud Consumer, Cloud Provider, Cloud Auditor, Cloud Carrier and Cloud Broker
- The **Cloud Broker** is a third party that interposes, in some cases, between the cloud provider and the cloud consumer. Specifically a cloud broker manages the delivery of cloud services from different providers to the consumer and negotiates the relationship.

Through the service of the broker, consumers (which interacts with the broker and not directly with the providers) can avoid the responsibility of interacting directly with the provider and can benefit from reducing the costs, by requesting services from multiple providers at the same time



# Deployment Models

- The deployment of a cloud infrastructure (and the corresponding services) can be arranged in a number of ways, depending on the requirements of the consumer organization
- Different models are usually related with the location of the infrastructure with respect to the organization and its access boundaries

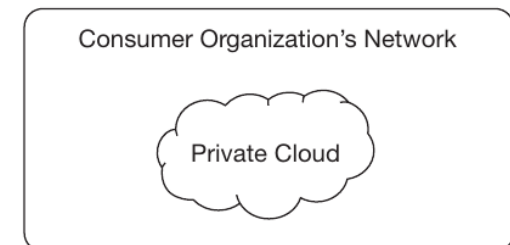


# Public clouds

- The public cloud deployment model is the most popular. In this model the cloud infrastructure (and the service) is managed by an external organization or enterprise that sell the service and the resources. In public clouds, referred also as external cloud, the infrastructure is placed off-premises, the users access the services remotely.
- Public clouds promote multi-tenancy at its highest level. The same physical resources are shared among multiple and unrelated consumers. This provide a big advantage for the cloud provider as it can serve with the same infrastructure a large number of consumer
- Public clouds make advantage of this proportion as they can reduce costs, and afford state-of-the-art technologies and skilled people

# Private clouds

- Private cloud deployments are not open, they are deployed and managed by a single organization for its internal use. The infrastructure is build with all the features of a cloud computing system, however, its access is restricted
- While a public cloud cannot physically reside at consumer's location, private cloud usually reside either inside consumer organization's premises or outside in any neutral location. Regardless, its management is on the responsibility of the consumer or on a trusted external company
- Private cloud deployments are adopted usually when the consumer wants specific control over the environment, or when there are specific requirements (e.g. sensitive data) are involved



# Public vs Private

- One major difference of private cloud with public cloud is that any private cloud shares one-to-one relationship with consumer while a public cloud maintains one-to-many relationship. In this case the feature of multi-tenancy does not apply.

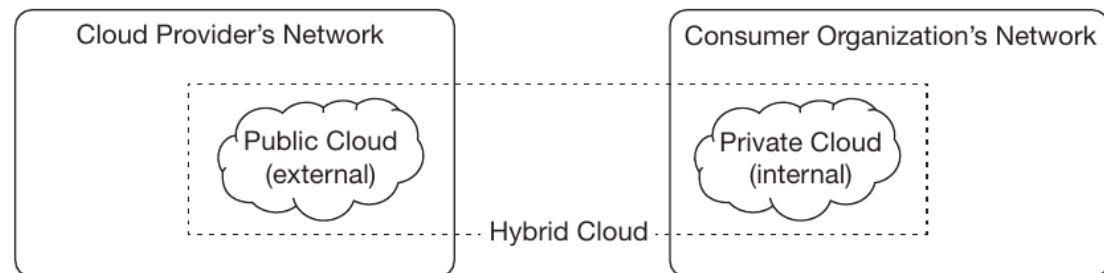
<i>Private Cloud</i>	<i>Public Cloud</i>
It can be both of types of on-premises and off-premises.	There cannot be any on-premises public cloud deployment.
On-premises private cloud can be delivered over the private network.	It can only be delivered over public network.
It does not support multi-tenancy feature for unrelated and external tenants.	It demonstrates multi-tenancy capability with its full ability.
The resources are for exclusive use of one consumer (generally an organization).	The resources are shared among multiple consumers.
A private cloud facility is accessible to a restricted number of people.	This facility is accessible to anyone.
This is for organizational use.	It can be used both by organization and the user.

# Community clouds

- Community cloud deployments allow access to a number of organizations or consumers belonging to a community. They are built and managed by a community of people or organizations that share common interests and goals.
- Such deployments are open only to the members of that community (like private clouds).
- Community cloud deployments might reside on-premises or off-premises, like private clouds they can be managed by members of the community or by some external computing vendors.
- Such deployments are a form of generalized private cloud.
- The model support multi-tenancy among the members of the community, the goal is to provide the benefits of public clouds, with the control of a private deployment
- Costs are shared among the members of the community, thus lower than private clouds
- The pay-per-use model can be applied

# Hybrid clouds

- Hybrid clouds are created by combining private or community cloud deployments with public cloud deployments
- This type of deployments helps organizations to get both the advantages of public and private deployments at once
- Hybrid clouds are formed by combining a private cloud infrastructure with a public one
- With hybrid clouds the consumer gets both low-cost computing and highly scalable resources and high level of control and privacy
- Cloud services can be deployed on the private and public part, or on both (part of the service)

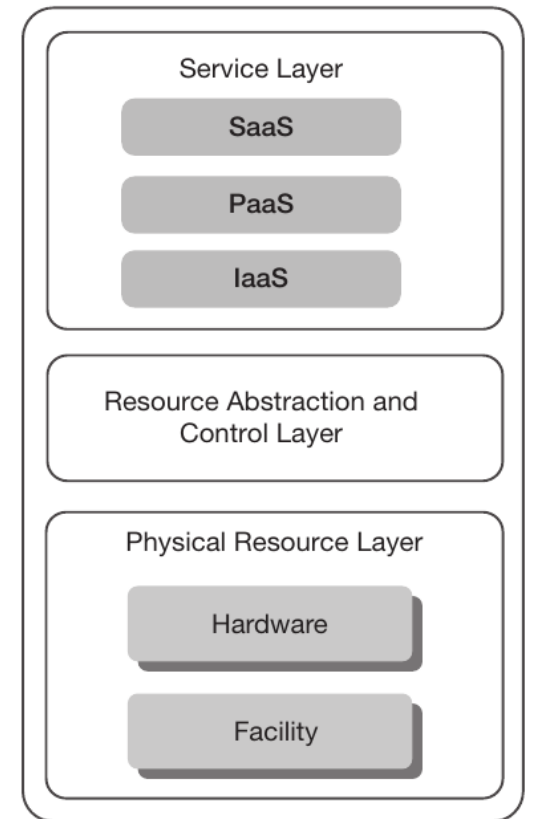


# Selecting the model

- The choice of the appropriate model depends on several factors
- Mainly it depends on the business needs (e.g. data security, low latency) and on the size of the consumer organization
- Consumers should carefully analyze their needs and the pros and cons for each deployment model and derive the requirements
- For general use any public cloud deployment is a good option
- Private/community deployments become an option when the company has concerns (or specific requirements) on data privacy or sensitive business related data
- Budget is another factor, the cost of migration and the cost of ownership of the infrastructure must be considered before selecting a deployment

# Service Delivery models

- The NIST reference architecture defines three models to deliver the service to consumers:
  - Infrastructure as a Service (IaaS)
  - Platform as a Service (PaaS)
  - Software as a Service (SaaS)
- Such delivery models are well established today and offered almost by each cloud provider in the market
- As a composition/evolution of these models there are available in the market additional delivery models
- *Delivery models differs each other on how the level of abstraction from the hardware infrastructure (the physical resource layer): from IaaS to SaaS we have an increasing level of abstraction*
- *Each model is characterized by a different set of aspects that the consumer has to take care*



# Conventional computing model

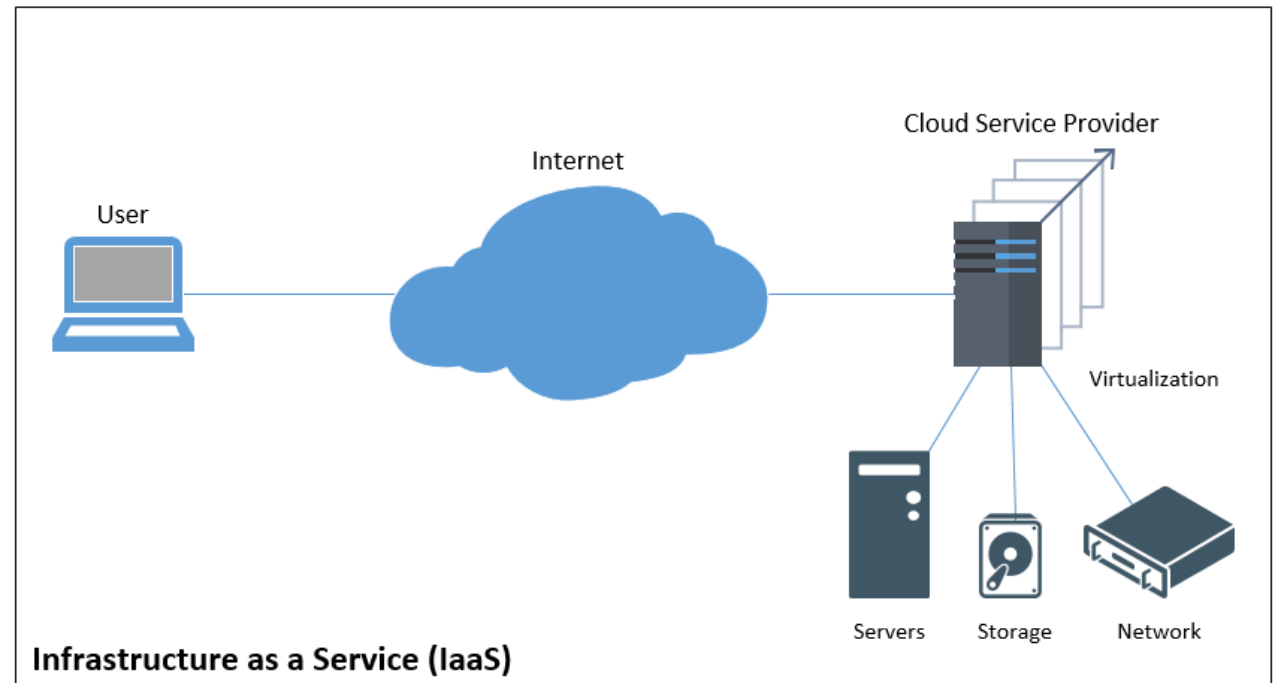
- In the conventional computing model you need to take care of :
  - Creating a physical infrastructure with servers, storage and network
  - Install and configure the operating systems on the servers
  - Install on each server a middleware/runtimes software to develop applications/services
  - Develop and deploy the service
  - Manage/store the data
- In the traditional computing service all these aspects are managed by the consumer





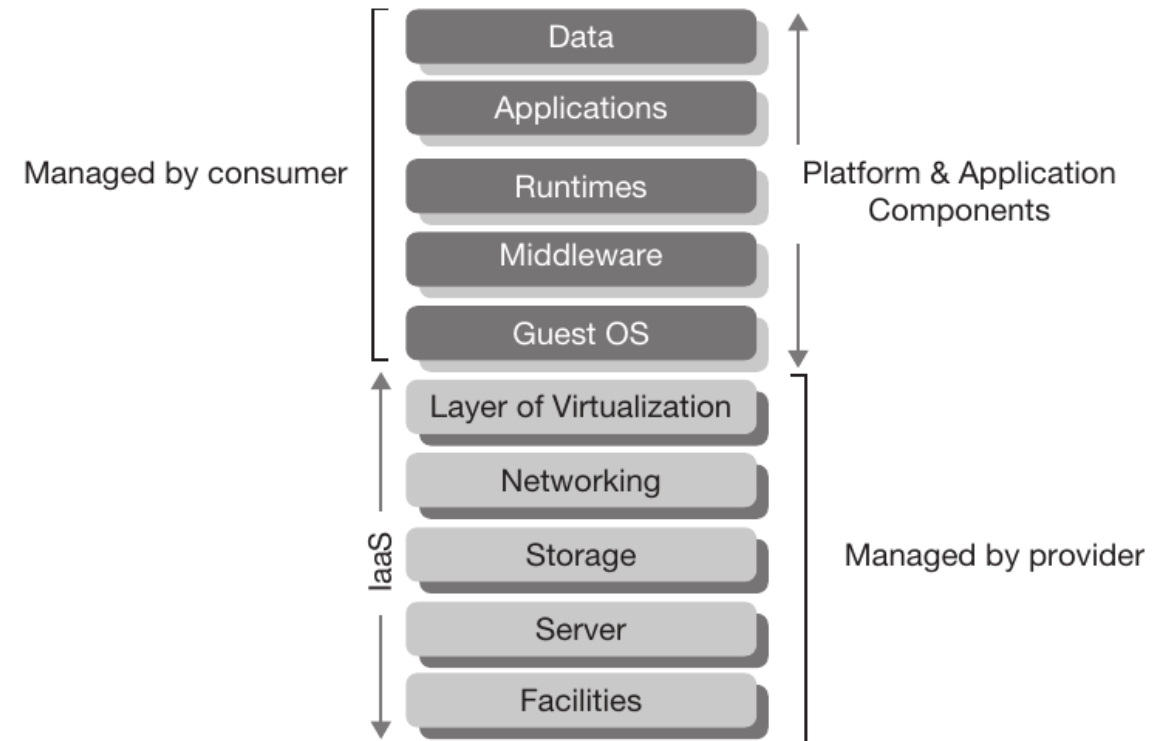
# Infrastructure as a Service (IaaS)

- Infrastructure as a Service delivers virtualized-hardware resources to consumers
- It provides the possibility of remotely using virtual processor, memory, storage and network resources
- These virtual resources can be used like the real hardware to create any computer setup (Virtual Machines)
- IaaS is also referred as Hardware as a Service (HaaS)



# Infrastructure as a Service (IaaS)

- Consumer no longer need to manage and control the computing infrastructure that is managed by the provider
- They still need to take care of all the components of the platform and the applications:
  - Installing an operating system on top of virtualized hardware
  - Configuring the middleware/runtime environment
  - Program and deploy the application
  - Manage the data

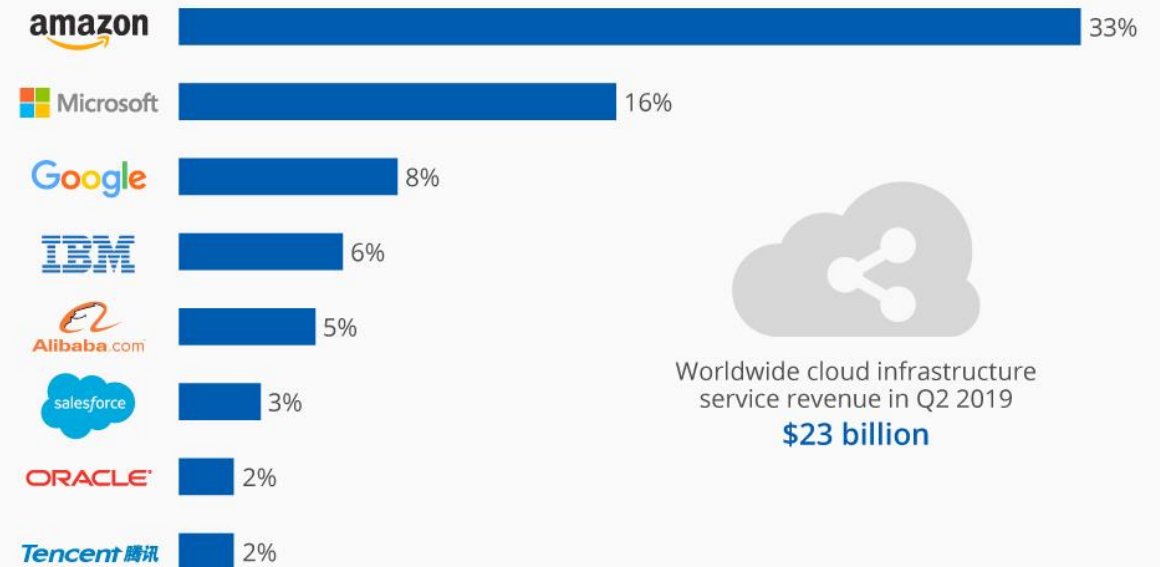


# Infrastructure as a Service (IaaS)

- IaaS removes costs to build and maintain the physical computing infrastructure, with good control on the environment on which services are deployed
- Major computing vendors all provide IaaS and it is the most used delivery model adopted

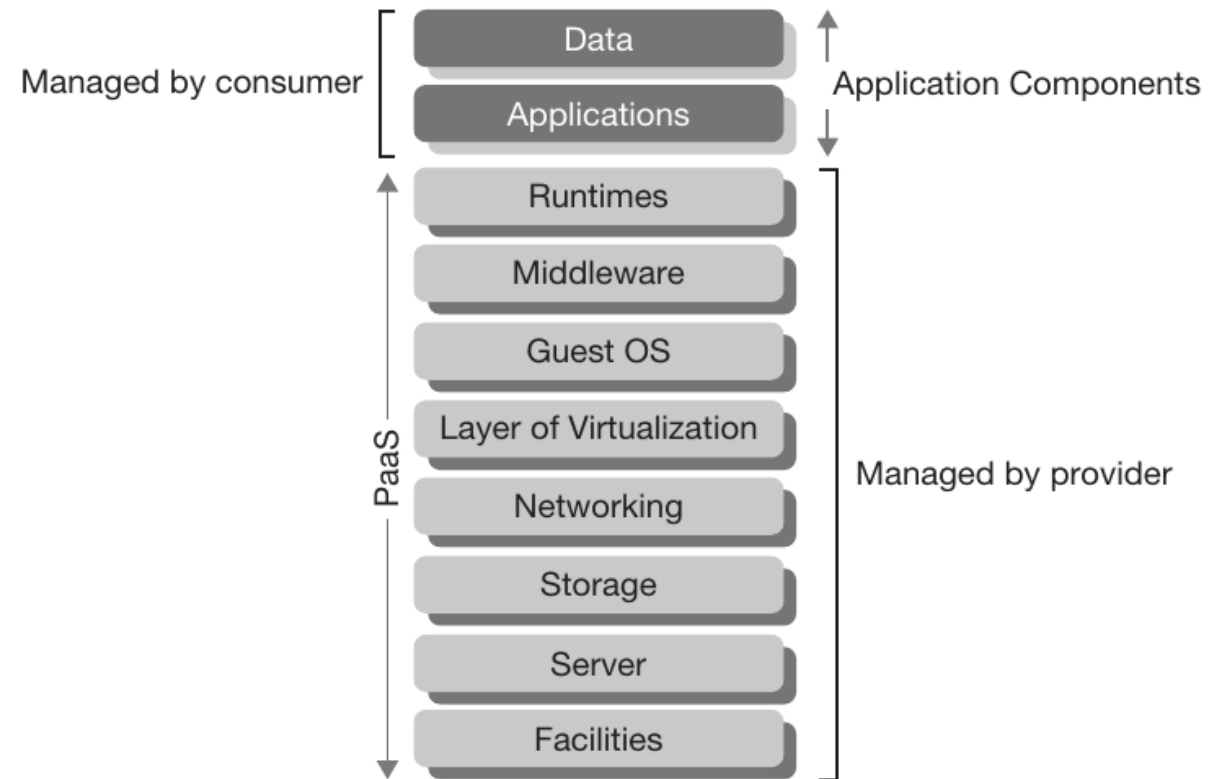
## Amazon Leads the Race to the Cloud

Worldwide market share of leading cloud infrastructure service providers in Q2 2019\*



# Platform as a Service (PaaS)

- Platform as a Service delivers access to a computing platform in which the consumer can design and develop the application components
- All the aspects from the physical infrastructure, to the installation of the operating system and a middleware/runtime platforms are managed by the provider
- Consumer has only to take care of programming the application logic and manage the data

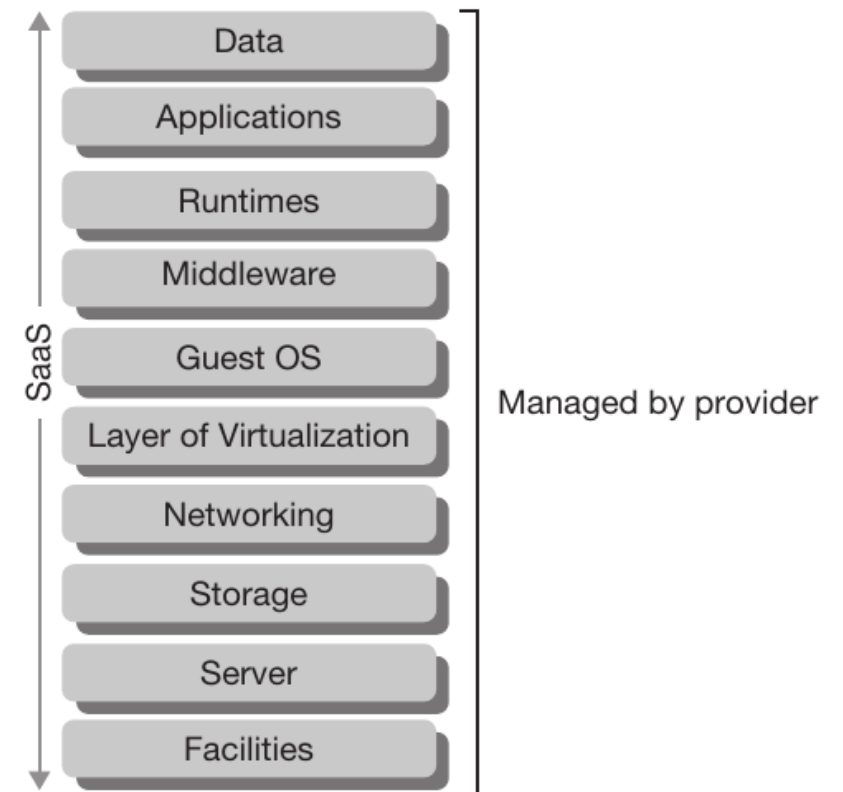


# Platform as a Service (PaaS)

- The consumer develop its application logic by using the programming environment provided by the cloud provider
- The consumer has to focus only on the application logic and data management without taking care of the middleware platform that is installed and configured
- The main drawback is the lack of flexibility: applications must be programmed using the APIs exposed by the system
- For this reason, applications programmed for one cloud platform can be hardly ported on a different cloud
- Google App Engine, Microsoft Azure Platform, Force.com are only examples of popular PaaS service

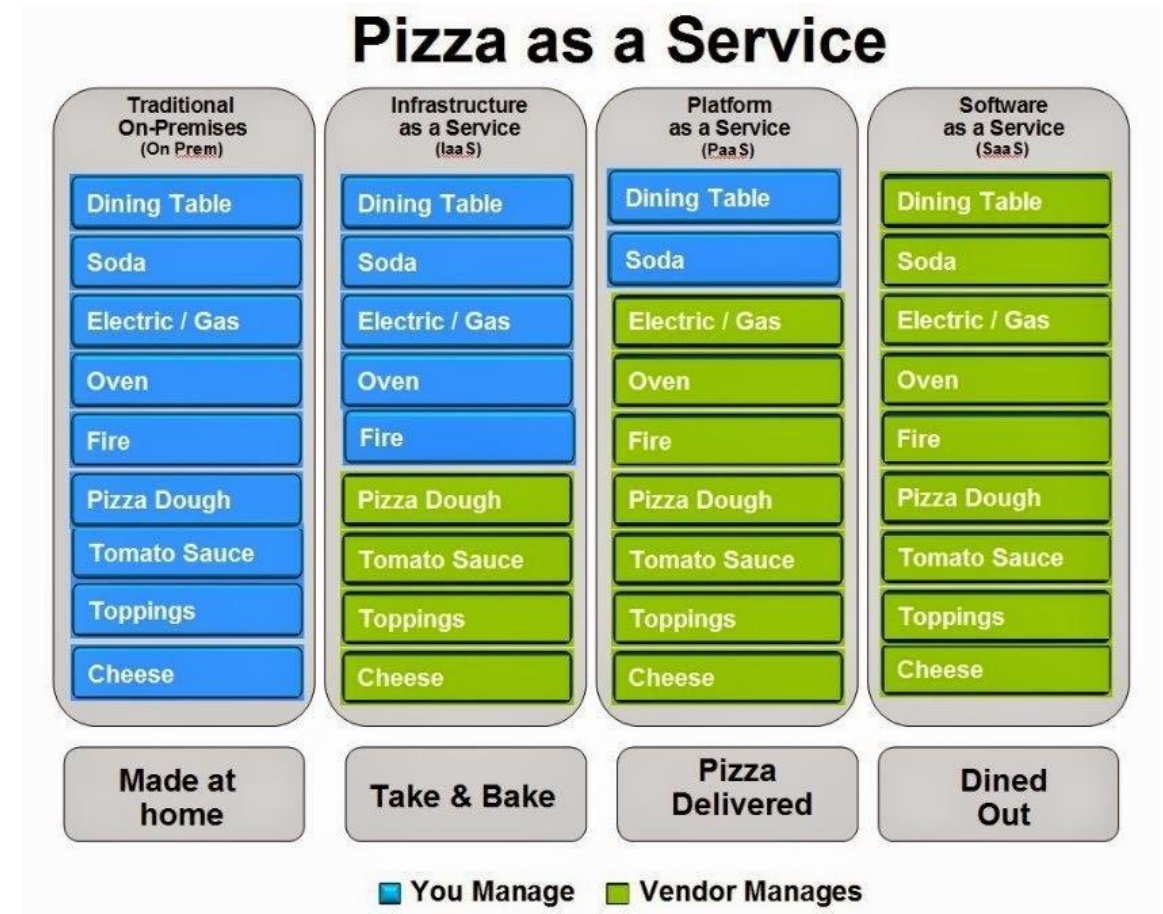
# Software as a Service (SaaS)

- In the Software as a Service mode the cloud provider delivers to consumers applications as a service
- Such applications developed by the cloud provider are offered usually via web interface to consumers, which uses thin clients (e.g. a web browser)
- In this model the cloud provider manages all the aspects of the system, from the hardware to the software development
- The consumer does not have to take care of anything, even software licensing that is managed by the provider

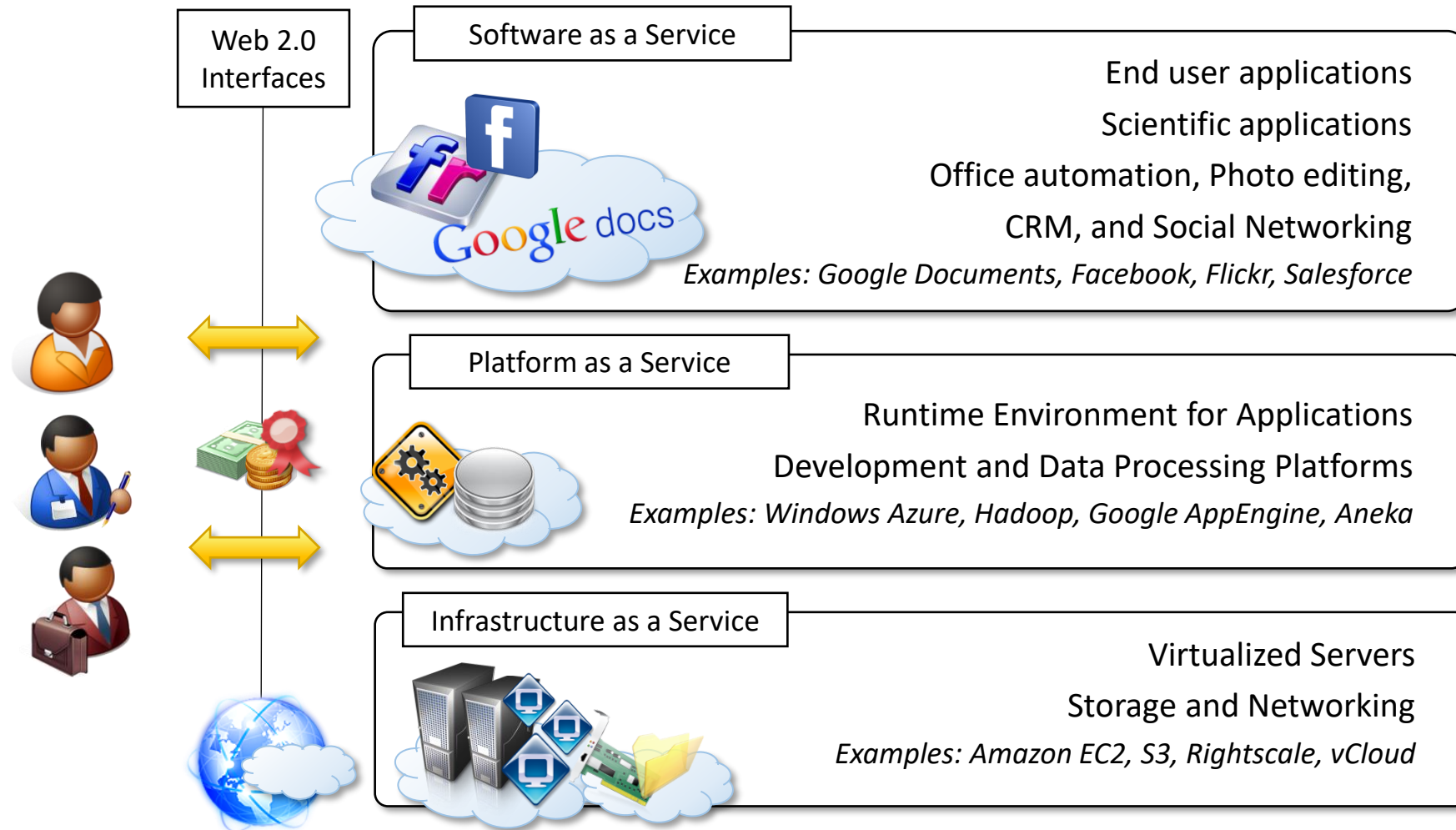


# Cloud/Pizza Delivery

- **Infrastructure as a Service**: IaaS provides virtual machines, virtual storage, virtual infrastructure, and other hardware assets as resources that clients can provision
- **Platform as a Service**: PaaS provides virtual machines, operating systems, applications, services, development frameworks, transactions, and control structures
- **Software as a Service**: SaaS is a complete operating environment with applications, management, and the user interface



# Model Examples



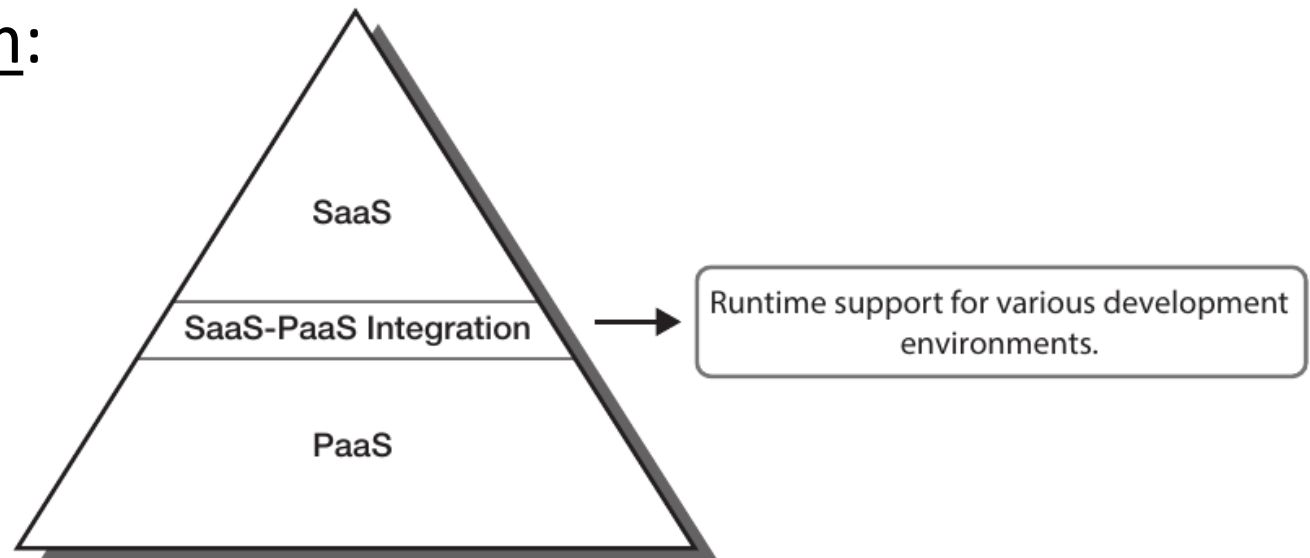


# PaaS/SaaS Implementation

PaaS and SaaS can be implemented on top of an IaaS infrastructure

An IaaS infrastructure can be used to create a PaaS infrastructure: VMs are created a software platform is installed on them

A PaaS infrastructure can be used to create a SaaS system:  
a PaaS platform is used to create a software that is provided as SaaS



# Other Cloud Services

- **Storage as a Service**: Data storage comes under IaaS offering. All of the IaaS service vendors offer storage services as an important part of their service. Data can be stored in cloud where the storage works like a disk drive and one can store files there like text, audio, video etc. Many cloud vendors offer independent storage services known as Storage-as-a-Service.
- **Database as a Service**: In cloud computing model, the database offering comes under the PaaS layer. But, the cloud service vendors have come up with exclusive cloud computing solution for database and it is called as Database-as-a-Service (DBaaS). DBaaS offers a unique platform with on-demand and self-service capability where even non-DBAs can easily fulfill their requirements.

# Other Cloud Services

- **Backup as a Service**: Data is core element of any business. Backing up and recovery of data is considered extremely important in computing but at the same time the system backup is also necessary to overcome uncertain circumstances like disaster and others. Backup is considered as a specialized service that asks for expertise and many cloud computing vendors offer backup-as-a-service (BaaS) that turns out to be most useful and cost-effective for the consumers.
- **Desktop as a Service**: There are cloud service providers who delivers personalized desktop environments to users as service. This allows users to enjoy the benefits of their personal desktop environment irrespective of the cloud access devices. This is also referred to as virtual desktop or hosted desktop.