



# Industry 4.0

**Topic: Core Technologies: Cloud Computing and Fog Computing**

# Cloud computing

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# What is computing?

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**Computing is the process of using computer technology to complete a given goal-oriented task.**

Computing may encompass the **design and development of software and hardware systems** for a broad range of purposes - often structuring, processing and managing any kind of information to aid in the pursuit of scientific studies, making intelligent systems, and creating and using different media for entertainment and communication.

the use of a computer to process data or perform calculations.

**It has scientific, engineering, mathematical, technological and social aspects.**

The list is virtually endless, and the possibilities are vast.....



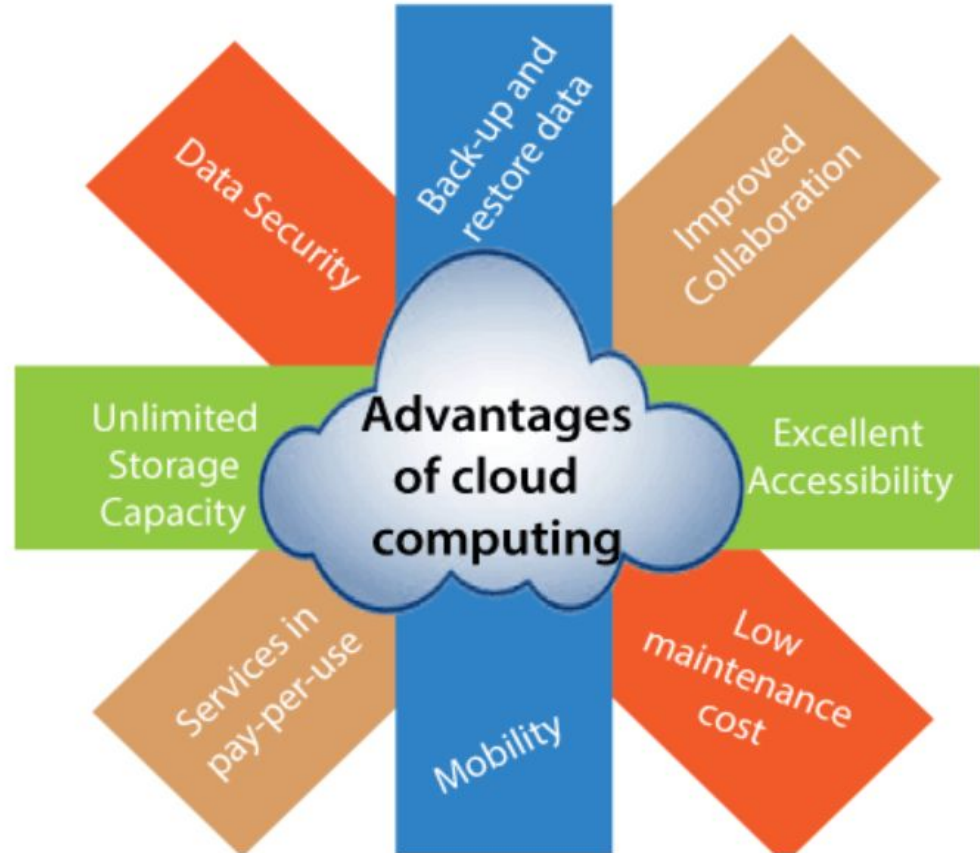
# What is Cloud Computing?

- **Cloud Computing** is a general term used to describe a new class of network based computing that takes place over the Internet,
  - a collection/group of integrated and networked hardware, software and Internet infrastructure (called a platform).
  - Using the Internet for communication and transport provides hardware, software and networking services to clients

# Cloud computing

- It provides a platform to facilitate the on-demand availability of computer system resources, particularly data storage (cloud storage) and processing power, without active administration by the users.
- Functions in large clouds are frequently spread over many locations, each of which is a data centre.
- It relies on resource sharing to achieve coherence and economies of scale, generally through a "pay-as-you-go" approach, which can reduce capital expenditures but also expose users to unanticipated operational expenses. Cloud helps businesses to get their applications up and running faster.
- Cloud computing allows you to put your complete computer infrastructure, including both hardware and software, online. It maintains data and apps via the Internet and remote central servers. The most simple and commonly used examples of cloud computing include Gmail, Yahoo mail, Facebook, Hotmail, Orkut, and others.

# Advantages of Cloud Computing



# Advantages of Cloud Computing

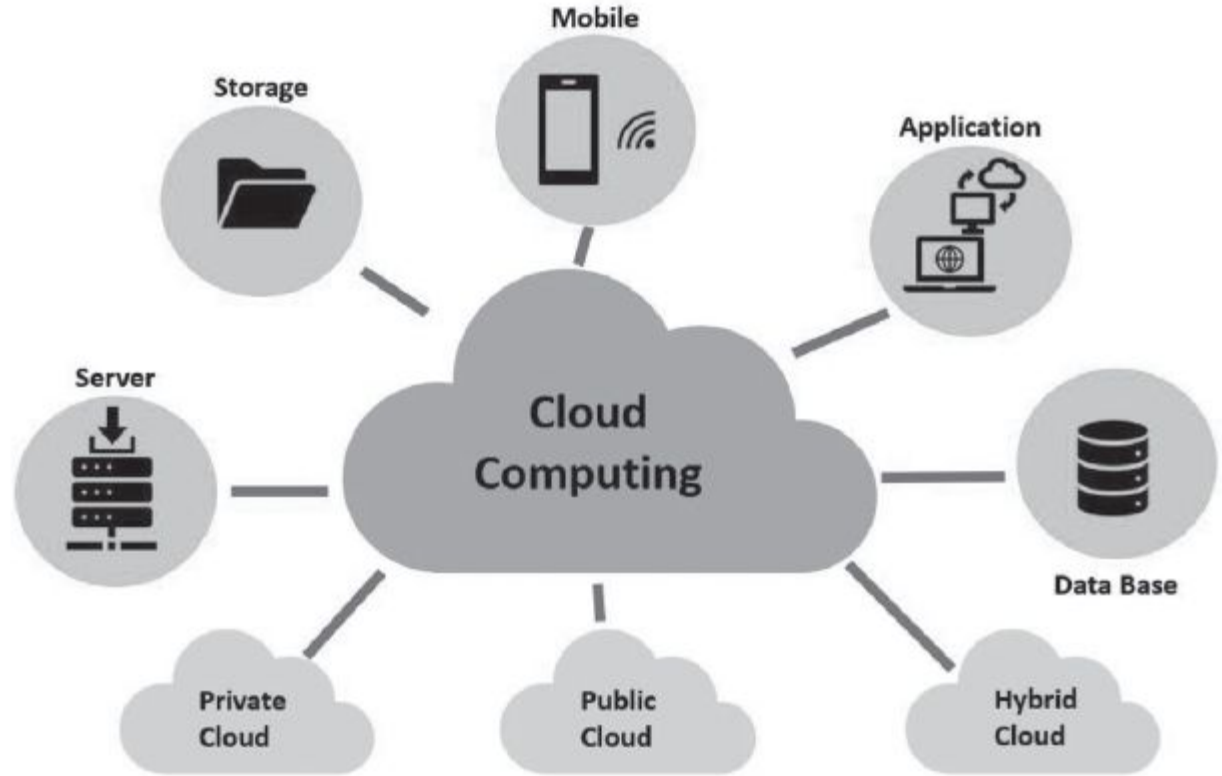
- 1) **Back-up and restore data:** Once the data is stored in the cloud, it is easier to get back-up and restore that data using the cloud.
- 2) **Improved collaboration:** Cloud applications improve collaboration by allowing groups of people to quickly and easily share information in the cloud via shared storage.
- 3) **Excellent accessibility:** Cloud allows us to quickly and easily access store information anywhere, anytime in the whole world, using an internet connection. An internet cloud infrastructure increases organization productivity and efficiency by ensuring that our data is always accessible.
- 4) **Low maintenance cost:** Cloud computing reduces both hardware and software maintenance costs for organizations.
- 5) **Mobility:** Cloud computing allows us to easily access all cloud data via mobile.
- 6) **Services in the pay-per-use model:** Cloud computing offers Application Programming Interfaces (APIs) to the users for access services on the cloud and pays the charges as per the usage of service.
- 7) **Unlimited storage capacity:** Cloud offers us a huge amount of storing capacity for storing our important data such as documents, images, audio, video, etc. in one place.
- 8) **Data security:** Data security is one of the biggest advantages of cloud computing. Cloud offers many advanced features related to security and ensures that data is securely stored and handled.

# Disadvantages of Cloud Computing

- 1) **Internet Connectivity:** As you know, in cloud computing, every data (image, audio, video, etc.) is stored on the cloud, and we access these data through the cloud by using the internet connection. If you do not have good internet connectivity, you cannot access these data. However, we have no any other way to access data from the cloud.
- 2) **Vendor lock-in:** Vendor lock-in is the biggest disadvantage of cloud computing. Organizations may face problems when transferring their services from one vendor to another. As different vendors provide different platforms, that can cause difficulty moving from one cloud to another.
- 3) **Limited Control:** As we know, cloud infrastructure is completely owned, managed, and monitored by the service provider, so the cloud users have less control over the function and execution of services within a cloud infrastructure.
- 4) **Security:** Although cloud service providers implement the best security standards to store important information. But, before adopting cloud technology, you should be aware that you will be sending all your organization's sensitive information to a third party, i.e., a cloud computing service provider. While sending the data on the cloud, there may be a chance that your organization's information is hacked by Hackers.

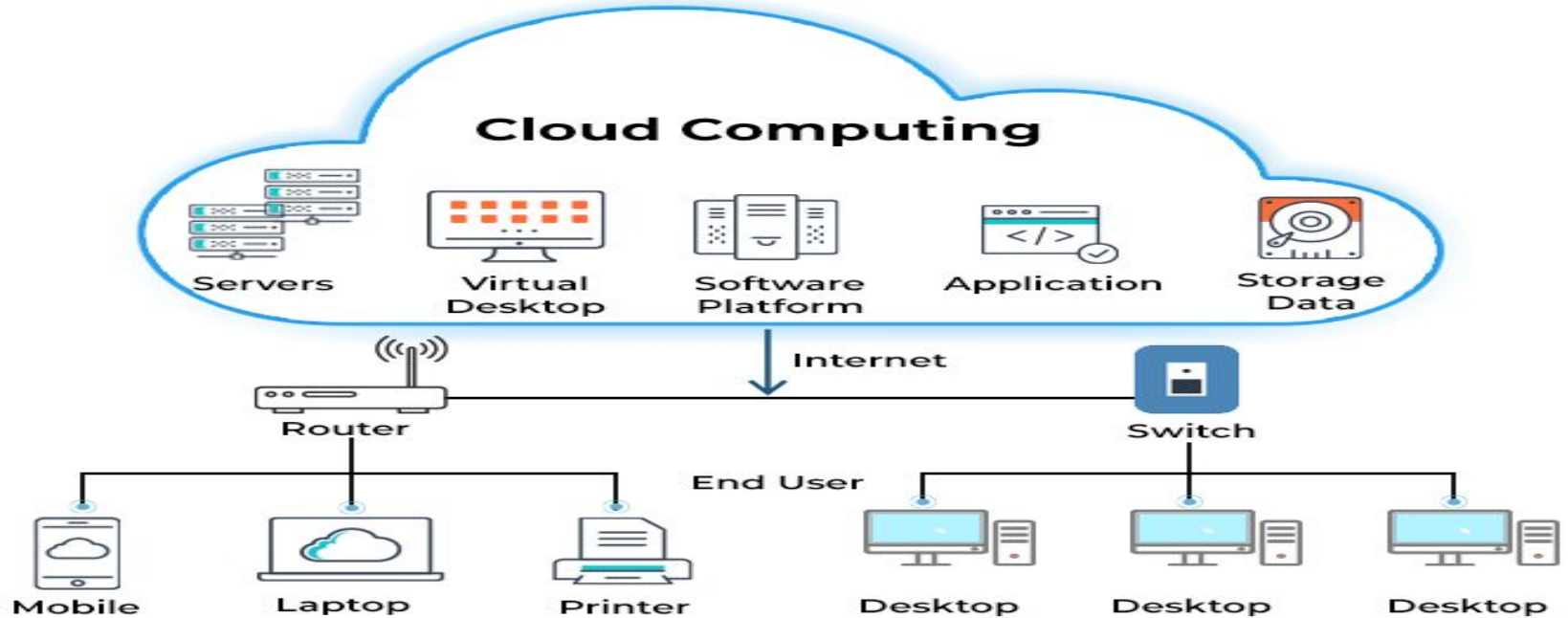


# Cloud Computing



Cloud computing.

# CLOUD COMPUTING ARCHITECTURE



01

Resources  
Pooling

02

On-Demand  
Self-Service

03

Easy  
Maintenance

04

Scalability  
And Rapid  
Elasticity

05

Economical

## Top 10 Major Characteristics of Cloud Computing

06

Measured And  
Reporting  
Service

07

Security

08

Automation

09

Resiliency And  
Availability

10

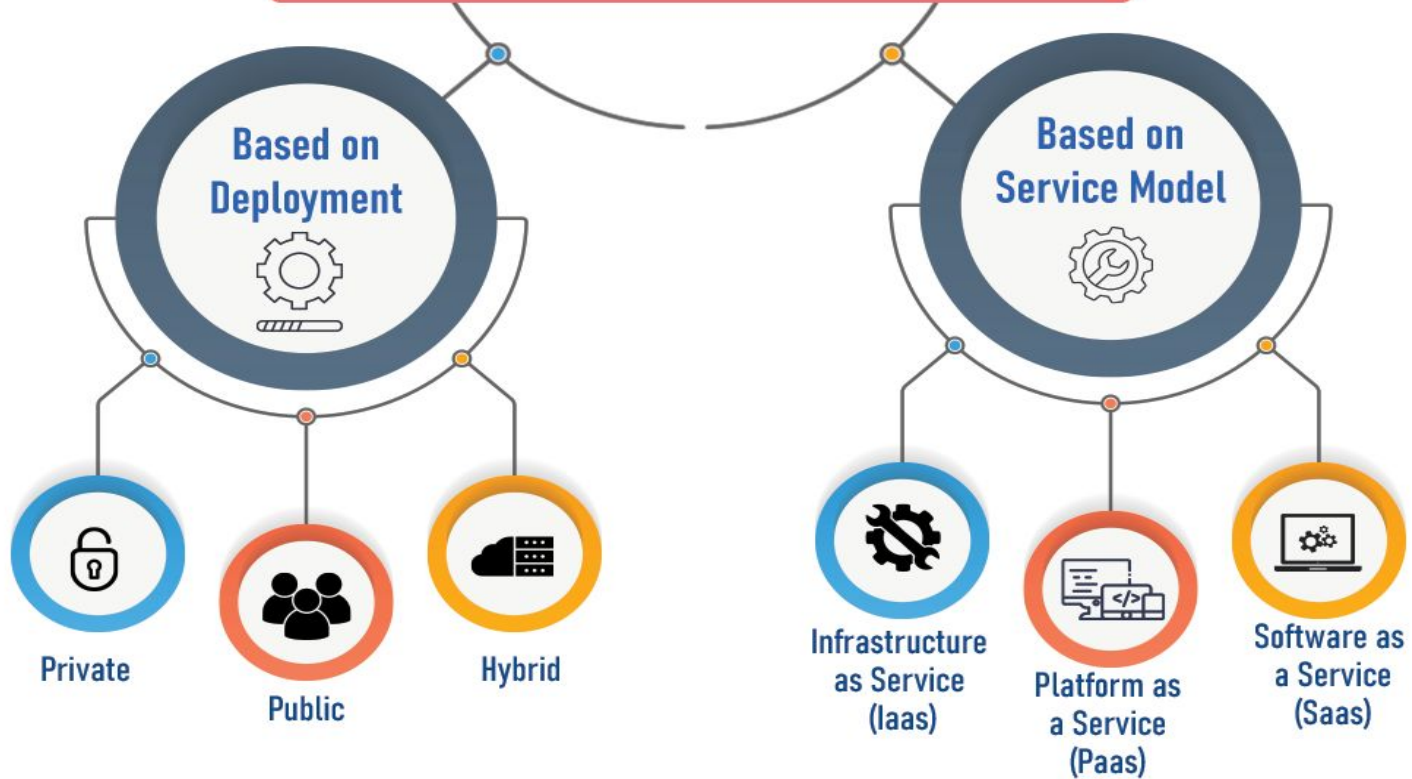
Large Network  
Access

# Basic Concepts

There are certain services and models working behind the scene making the cloud computing feasible and accessible to end users. Following are the working models for cloud computing:

- Deployment Models
- Service Models

# TYPES OF CLOUD COMPUTING



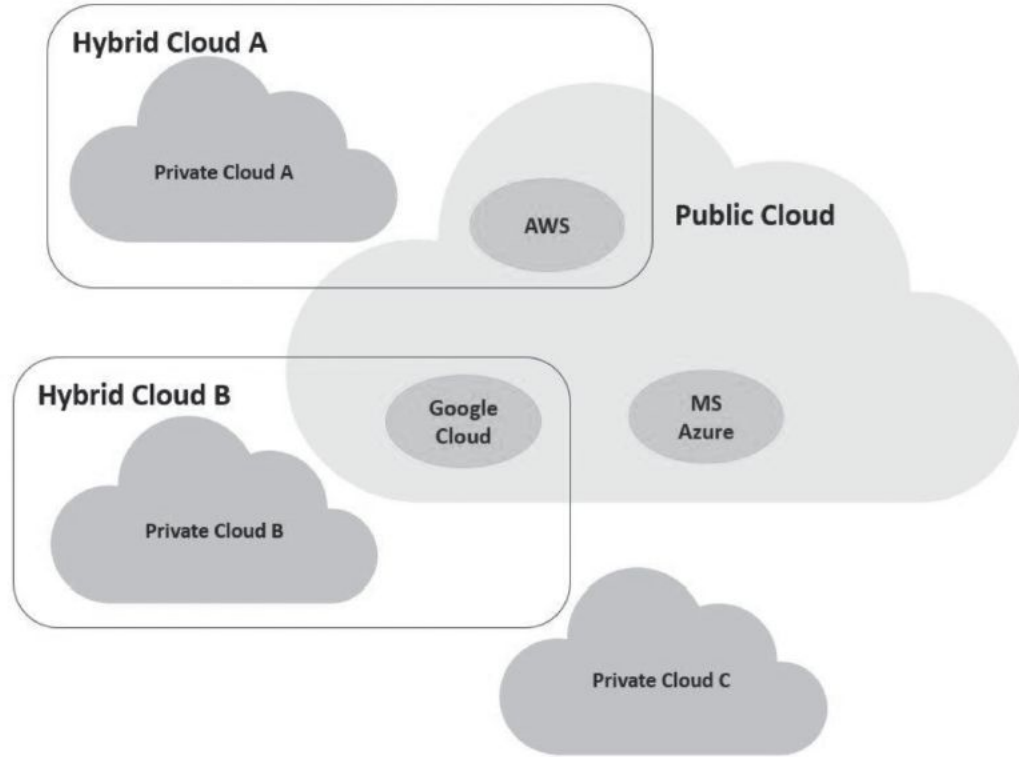


### 3.8 Cloud Service Model by Type of Deployment



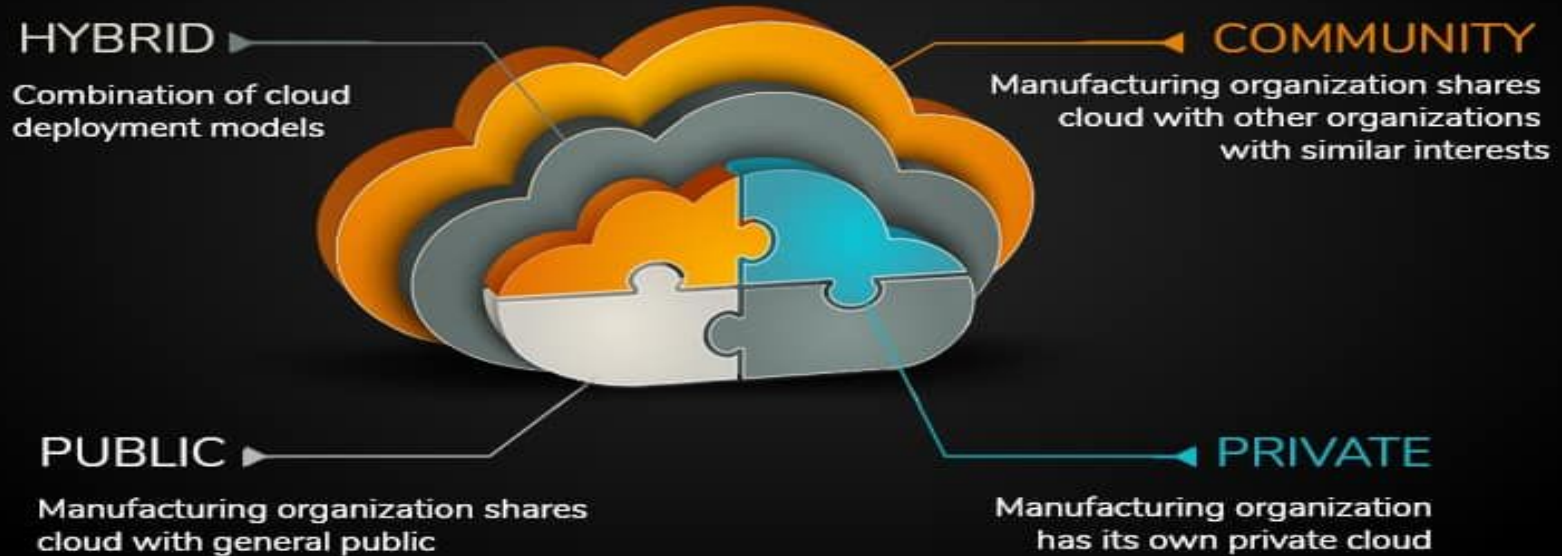
# Cloud service model by type of Deployment

There are three types of cloud service based on their deployment model.



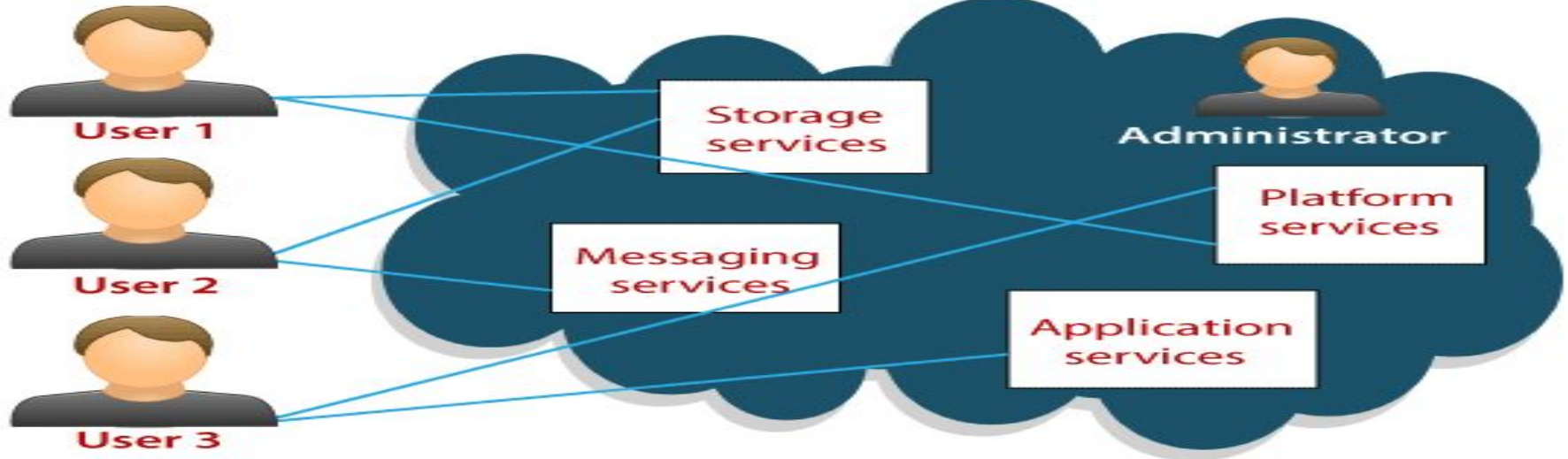
**FIGURE 3.5.** Cloud service model example.

# Cloud Deployment Models





# Public Cloud



## Features of Public Cloud





# Hybrid Cloud – Leveraging Both Public & Private Cloud



## PRIVATE CLOUD

Benefits:

- ✓ Fully Customizable
- ✓ Robust Management
- ✓ Secure by Design



## PUBLIC CLOUD

Benefits:

- ✓ Low Entry Cost
- ✓ Pay As You Go
- ✓ Highly Elastic



## HYBRID CLOUD = BETTER OUTCOMES

Benefits:

- ✓ Scalability
- ✓ Flexibility

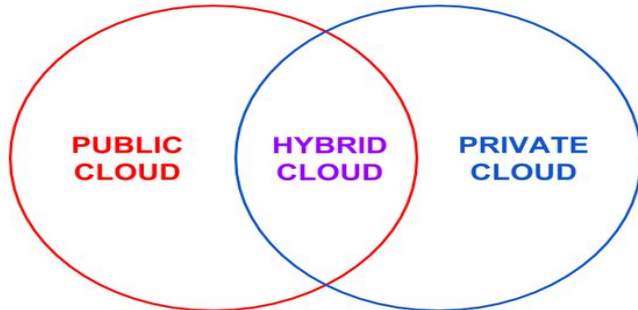
- ✓ Security
- ✓ Cost efficiency

# Hybrid Cloud

## Top 5 Hybrid Cloud Providers:

- Amazon
- Microsoft
- Google
- Cisco

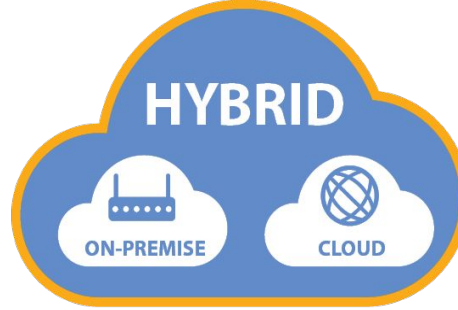
### Best Hybrid Cloud Tools





## PUBLIC CLOUD

- Services are owned and operated by cloud provider (no CAPEX, no ongoing maintenance costs).
- Cloud providers have data centres located at different regions across the world (high redundancy, close to customers).
- Provision of resources in minutes and usage on as need basis (highly scale).
- Lesser security as the platform is shared.
- Lesser flexibility and control over cloud environment.



## HYBRID CLOUD

- Businesses can keep data which needs to be secured by their standards in their on-premise environment.
- Greater flexibility and more deployment options.
- Extend on-premise infrastructure to the cloud without making further capital investments.
- Network complexities and potential compliance issues
- Can be very expensive.



## PRIVATE CLOUD

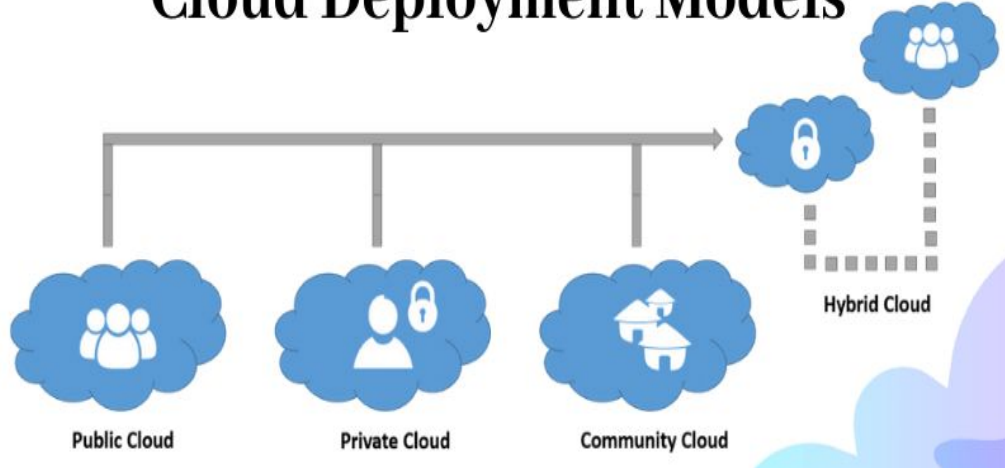
- Business has complete control over the environment.
- Business can implement its own security protocols at every layer.
- Data is held in environment that is in complete control by business.
- Purchase and maintenance have to be bared by business.
- More expensive than public cloud.

# Cloud Deployment Model Comparison

	Public Cloud	Private Cloud	Community Cloud	Hybrid Cloud
Setup and Use	Handle In-house	Requires IT Professionals	Requires IT Professionals	Requires IT Professionals
Privacy and Security	Low	High	Medium	Varies from low to high
Control of Data	Low	High	Medium	Medium
Overall Reliability	Medium	High	Medium	Medium to high
Flexibility and Scalability	High	Medium (stable capacity)	Medium (stable capacity)	Very high
Cost	Lowest	Relatively high	Variable	Medium/Variable
Hardware	Third-party	Variable (can be on-site or third-party)	Variable	Medium/Variable

# Deployment Models

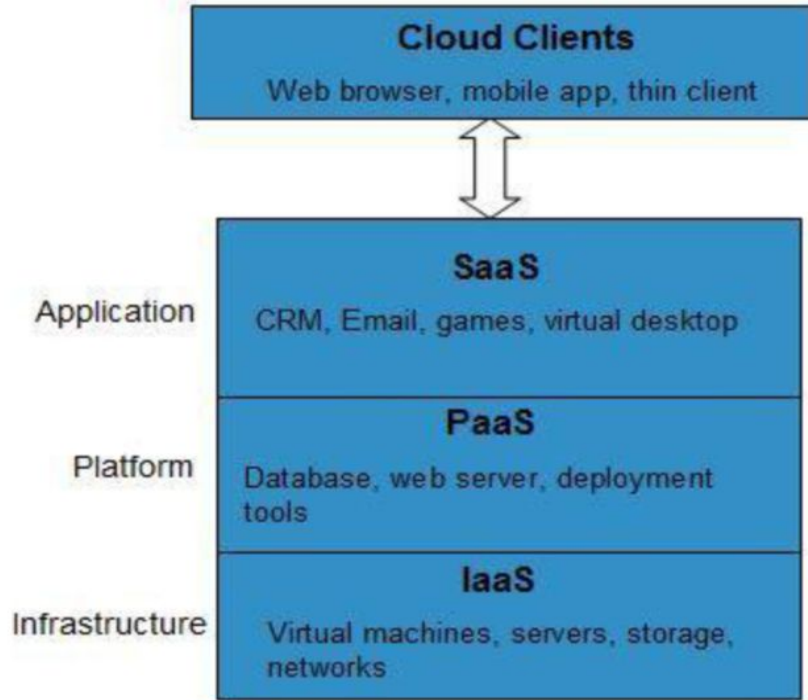
## Cloud Deployment Models



- The **Public Cloud** allows systems and services to be easily accessible to the general public. Public cloud may be less secure because of its openness, e.g., e-mail.
- The **Private Cloud** allows systems and services to be accessible within an organization. It offers increased security because of its private nature.
- **Community Cloud** -The Community Cloud allows systems and services to be accessible by group of organizations.
- The **Hybrid Cloud** -is mixture of public and private cloud. However, the critical activities are performed using private cloud while the non-critical activities are performed using public cloud.



# Service Models



## INFRASTRUCTURE AS A SERVICE (IAAS)

- IaaS provides access to fundamental resources such as physical machines, virtual machines, virtual storage, etc.

## PLATFORM AS A SERVICE (PAAS)

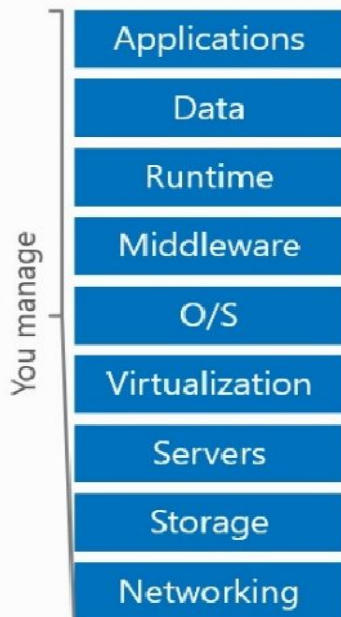
- PaaS provides the runtime environment for applications, development & deployment tools, etc.

## SOFTWARE AS A SERVICE (SAAS)

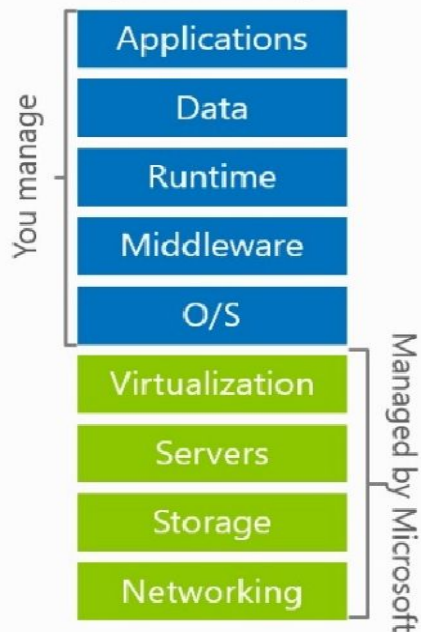
- SaaS model allows to use software applications as a service to end users

# Cloud Models

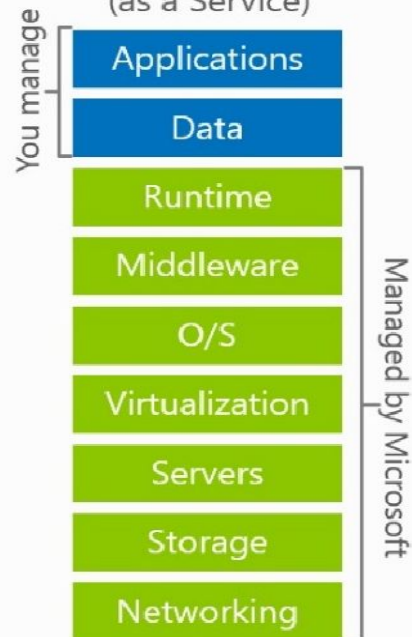
## On Premises



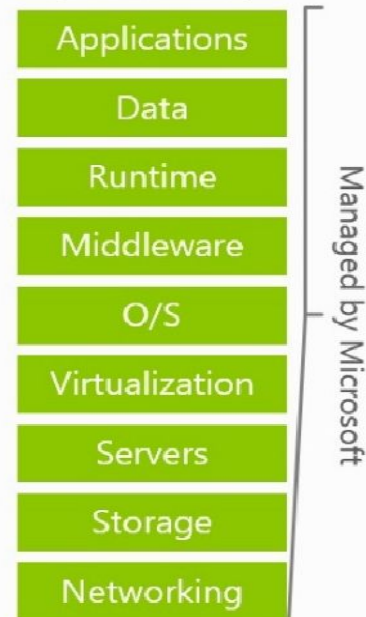
## Infrastructure (as a Service)



## Platform (as a Service)



## Software (as a Service)



Applications

Middleware/OS

Servers

**IaaS**  
host



Applications

Middleware/OS

Servers

**PaaS**  
build



Applications

Middleware/OS

Servers

**SaaS**  
Consume



SaaS

PaaS

IaaS

Users

Software  
developers

System administrators  
Network architects

Software as a  
Service (SaaS)

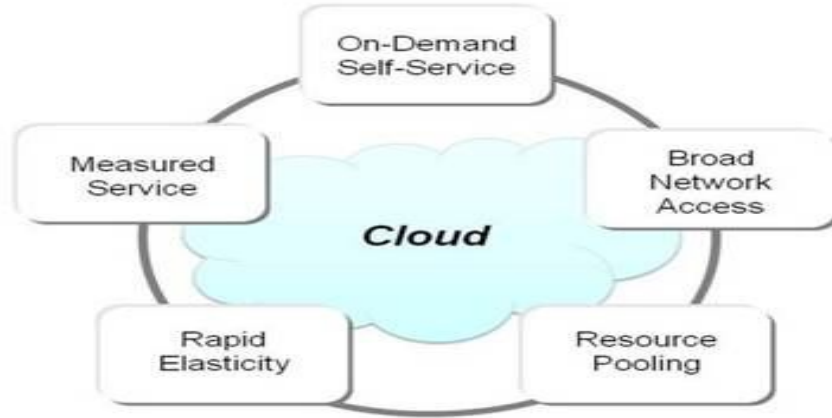
Platform as a  
Service (PaaS)

Infrastructure as  
a Service (IaaS)

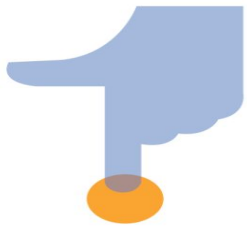




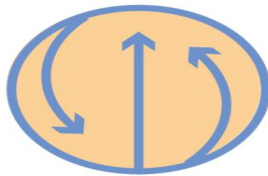
# Characteristics of Cloud



## 5 Essential Characteristics of Cloud Computing



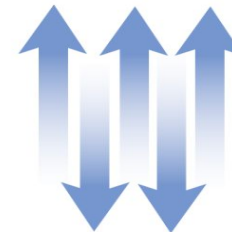
On-demand Self-service



Ubiquitous Network Access



Location Transparent Resource Pooling



Rapid Elasticity



Measured Service with Pay-per-Use



# Characteristics of Cloud



## A) On demand self services:

- i. computer services such as email, applications, network or server service can be provided **without requiring human interaction with each service provider.**
- ii. Cloud service providers providing on demand self services include **Amazon Web Services (AWS), Microsoft, Google, IBM and Salesforce.com.**

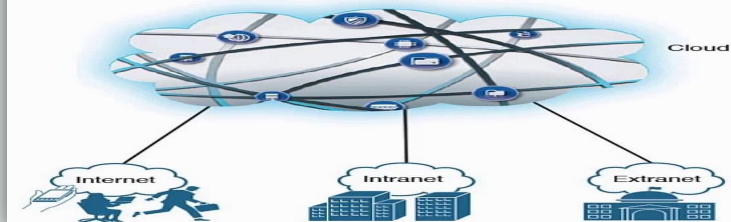
## B) Broad network access:

- i. Cloud **Capabilities** are **available over the network** and
- ii. **accessed** through standard mechanisms that **promote use by heterogeneous thin or thick client platforms** such as mobile phones, laptops and PDAs.

### ON-DEMAND SELF-SERVICE



### Broad Network Access



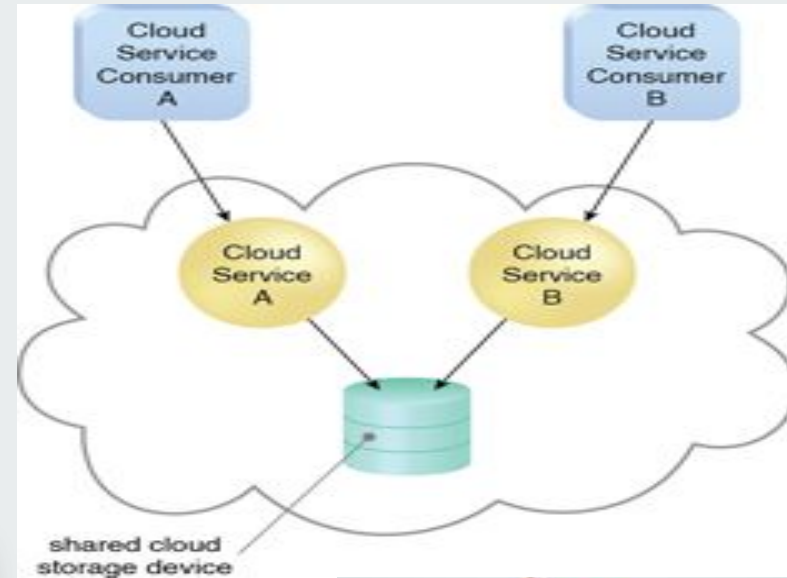


# Characteristics of Cloud

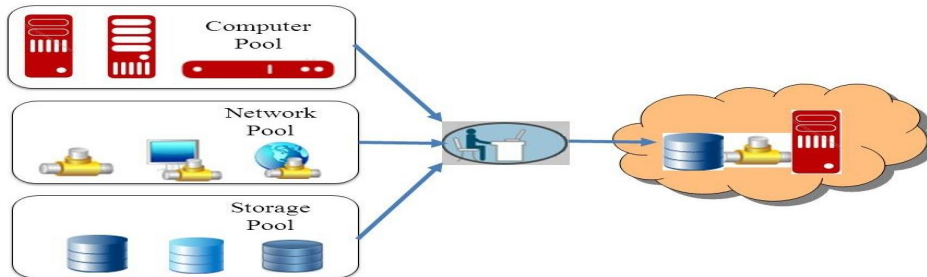


## C) Resource pooling:

- i. The provider's computing resources are pooled together to **serve multiple consumers** using **multiple-tenant model**, with **different physical and virtual resources** dynamically assigned and reassigned according to consumer demand.
- ii. The resources include storage, processing, memory, network bandwidth, virtual machines and email services as mobile phones, laptops and PDAs.



### Resource Pooling



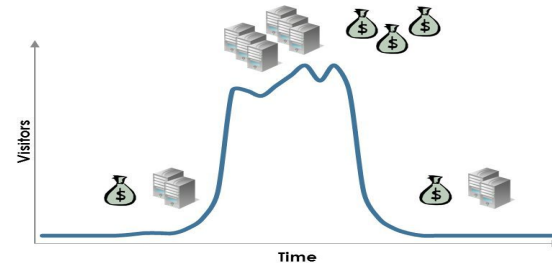
# Characteristics of Cloud

## D) Rapid elasticity:

- i. Cloud services can be rapidly and elastically provisioned, in some cases automatically to quickly scale out and rapidly released to quickly scale in.
- ii. **To the consumer, the capabilities available for provisioning often appear to be unlimited and can be purchased in any quantity at any time.**
- iii. Rapid elasticity allows users to automatically request additional space in the cloud or other types of services. Because of the setup of cloud computing services, provisioning can be seamless for the client or user.

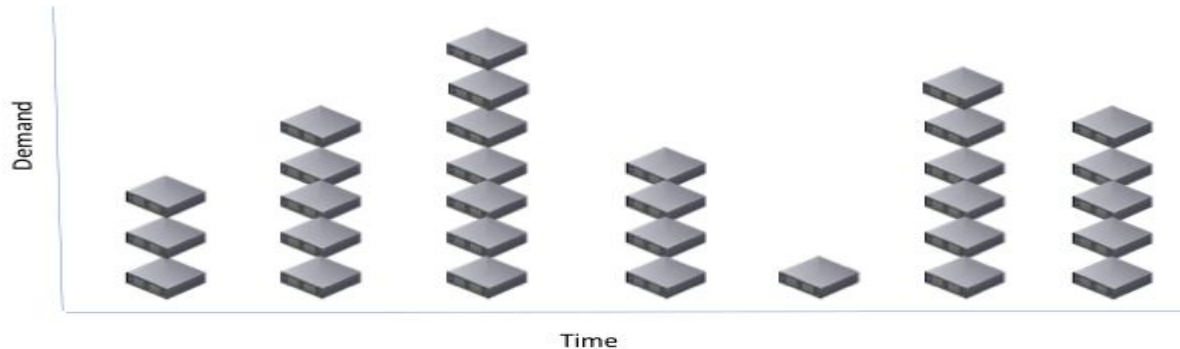


RAPID ELASTICITY



# Characteristics of Cloud

- Elasticity allows the cloud provider's customers to achieve cost savings and this is often a core reason for adoption of cloud services
- *Example - Say that 10 servers are required for a three month project. With cloud services the company can provision them within minutes, pay a small monthly operation + execution fee to run them rather than a large upfront capital investment cost, and decommission them at the end of the three months with no further charge.*



# Benefits

## Top benefits of **CLOUD** computing in **2020** and beyond

**HealthyIT**



The cloud reduces  
operational issues



The cloud increases  
team collaboration



The cloud saves  
you money



The cloud  
improves security



The cloud is  
sustainable



Security Issues



Management Issues



Lack of Expertise



Performance Issues



Migration

## Disadvantage of **Cloud** Computing



# The Edge of the Cloud

- **Why isn't cloud computing sufficient for some applications?**
  - **Latency** – Real-time interaction
    - Video Streaming – Movies, Video Conferencing
    - Gaming – Role playing games
    - Augmented Reality – Pokémon Go
  - **Geographical Distribution** – Widely distributed deployments
    - Massively Multiplayer Online Real-time Games
    - Route Planning / Traffic
  - **Mobile Deployment** – Nodes will be moving
    - Cell phones
    - Vehicles
  - **Large number of Nodes**
    - Networks of sensor nodes



# Fog Computing

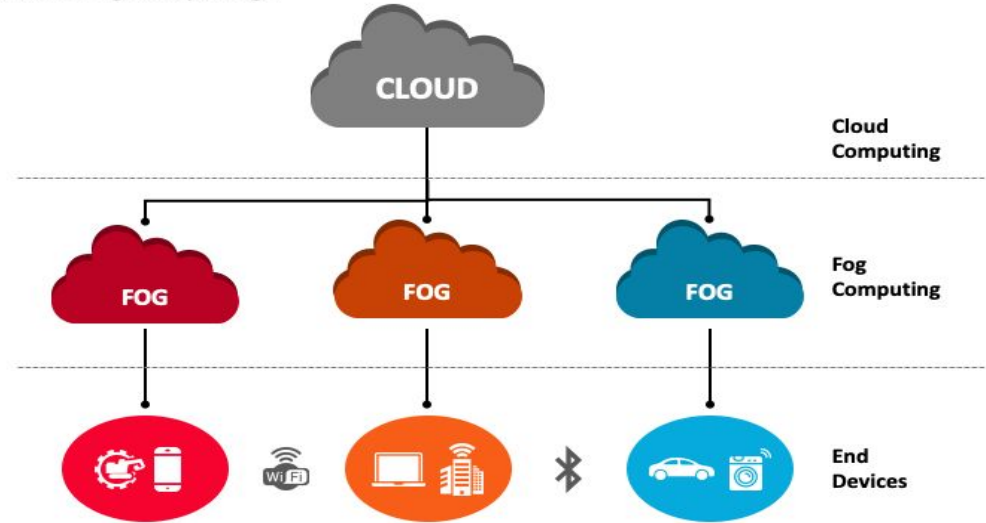
Fog platform provides low-latency virtualized services and is linked to the Cloud Computing infrastructure.

Edge devices request compute, storage and communication services from the Fog. The Fog provides local, low-latency response to these requests and forwards relevant data for computationally intensive processing.

## FOG COMPUTING

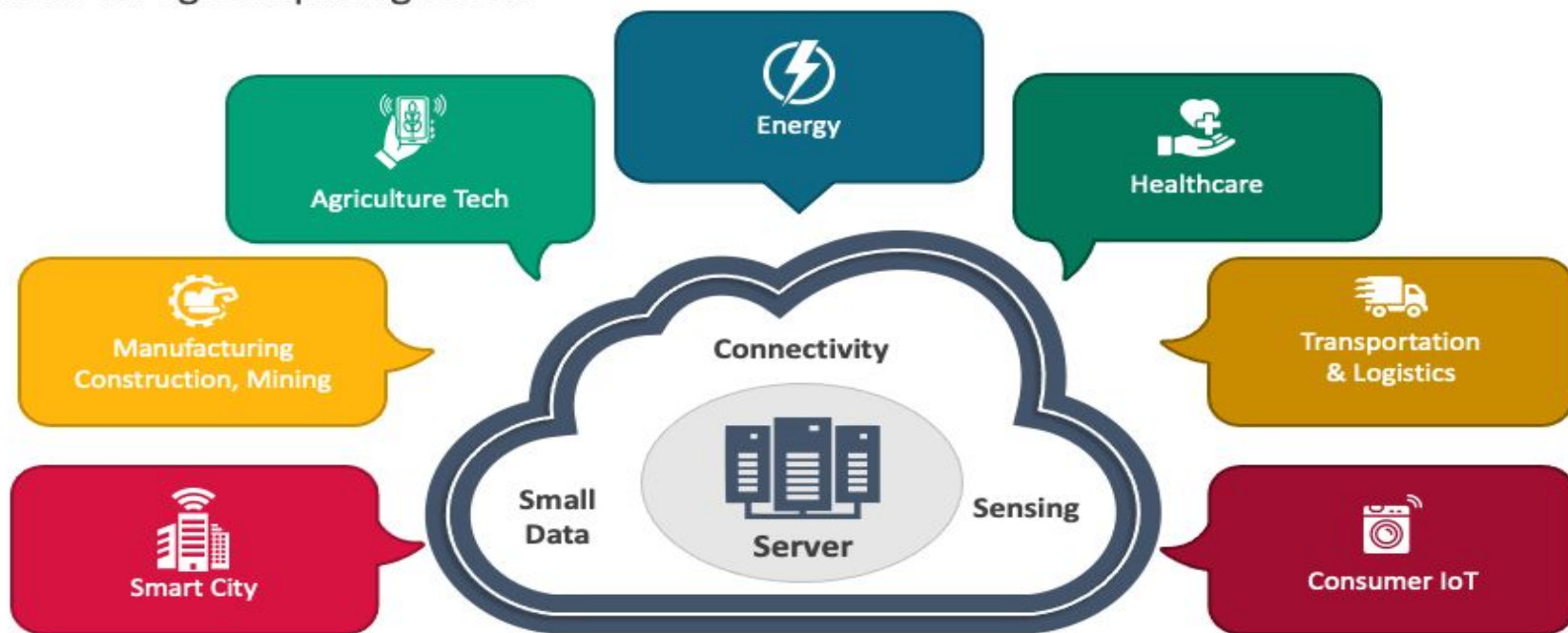
What is Fog Computing?

Source: Network interview.com



# FOG COMPUTING

Where is Fog Computing Used?



# FOG COMPUTING CHARACTERISTICS:

- **Low Latency** – Video Delivery, Navigation Information
- **Location Awareness** – Traffic Lights, Navigation, Sensor Networks
- **Wide-spread Geographical Distribution**
- **Mobility** – Fitness Trackers, Phones and Vehicles

# Fog Computing Characteristics:

- Predominance of **Wireless Access**



- Strong presence of **Streaming** and **Real-time Applications**
- **Heterogeneity**

# Architectural Drivers

- **Low Latency / Real Time Response** – Device will want near real-time response for content delivery and actionable information
- **Dynamic Number of Nodes** -- Number of devices within the Fog is dynamic. System must be able to handle large number of devices joining and leaving the Fog
- **Highly Mobile Nodes** – Nodes will be entering and exiting the Fog and the Fog must adapt and continue to perform
- **Diverse Set of Failure Modes** – Wide range of devices with varying levels of sophistication mean there will be many failure modes that need to be seamlessly handled
- **Security** – Access control

# FOG COMPUTING

## Pros and Cons of Fog Computing



### Pros

Reduces the amount of data sent to the cloud.

Conserves network bandwidth.

Improves system response time.

Improves security by keeping data close to the edge.

Supports mobility.

Minimizes network and internet latency.



### Cons

Physical location takeaway from the anytime, anywhere, any data benefit of the cloud.

Security issues: IP address spoofing, man-in-the-middle attacks.

Privacy issues.

Availability/ cost of log equipment/ hardware.

Trust and authentication concerns.

Wireless network security concerns.

# Edge Computing with Fog Computing and Cloud Computing

This slide represents the difference between edge computing, fog computing, and cloud computing based on the location of data processing, processing power, and storage capacity and purpose.



Factors	Edge Computing	Fog Computing	Cloud Computing
<ul style="list-style-type: none"> <li>Location of Data Processing</li> </ul>	Data processing takes place at the edge of the network	Edge computing tasks related to LAN hardware are moved further away from the sensors using fog computing	Information is processed on the cloud server
<ul style="list-style-type: none"> <li>Processing Power &amp; Storage Capabilities</li> </ul>	Storage capacity and processing power is limited for IoT devices and sensors	Limited storage capacity and processing power	High-level and extremely powerful processing technology and can store more data
<ul style="list-style-type: none"> <li>Purpose</li> </ul>	Quick analysis and real-time response	Quick analysis and real-time response	Well-suited to long-term, in-depth data analysis, and storage
<ul style="list-style-type: none"> <li>Add text here</li> </ul>	Add text here	Add text here	Add text here

# What is Fog Computing?

---

- The term "fog computing" refers to a decentralized computing architecture or method where computer resources are dispersed between the data source and the cloud or other data center and the data center itself. A paradigm known as fog computing responds to user queries at edge networks. Typically, the hubs, routers, gateways, and other networking-related equipment at the fog layer carry out networking-related tasks. According to researchers, these gadgets are expected to be capable of concurrent processing and networking tasks. Despite these devices having fewer available resources than cloud servers, their geographical dispersion and decentralized nature enable them to provide dependable services with widespread coverage. The physical location of the devices in fog computing is significantly closer to the consumers than cloud servers are.



Feature	Fog Computing	Cloud Computing
Latency	The latency of fog computing is minimal.	When compared to fog computing, cloud computing has a significant latency.
Depending on how well the core network performs	Effective in a weak network core	A robust network core is necessary
Capacity	Fog Computing minimizes the quantity of data supplied to cloud computing.	Cloud computing does not offer any reduction in data when transmitting or converting data

Feature	Fog Computing	Cloud Computing
Communication mode	WLAN, Wi-Fi, 3G, 4G, ZigBee, and other types of wireless or wired connection (part of the IP networks)	IP Network
Responsiveness	The system's response time is quick.	System response times are slow.
Working environment	Specific air conditioning systems in a data center building	Outdoor (streets, base stations, etc.) or indoor (houses, cafés, etc.)
Security	Fog computing has higher security than cloud computing	Cloud computing has less security

Feature	Fog Computing	Cloud Computing
Place of service	Services are offered at the local network's perimeter.	Internet-based services are offered.
Speed	More expensive than cloud computing.	Access speed depends on the connection of the virtual machine.
Geographical Spread	It is scattered and decentralized.	It is centrally located.
Data Integration	It is possible to combine several data sources and devices.	Integration of several data sources is possible.
Number of Server Nodes	Numerous server nodes are used in fog computing.	There are not many server nodes in cloud computing.

Feature	Fog Computing	Cloud Computing
Mobility	Fog computing supports mobility.	Mobility in cloud computing is constrained.
Geographic Awareness	Aided by fog computing	Partially cloud computing is supported.

## Conclusion

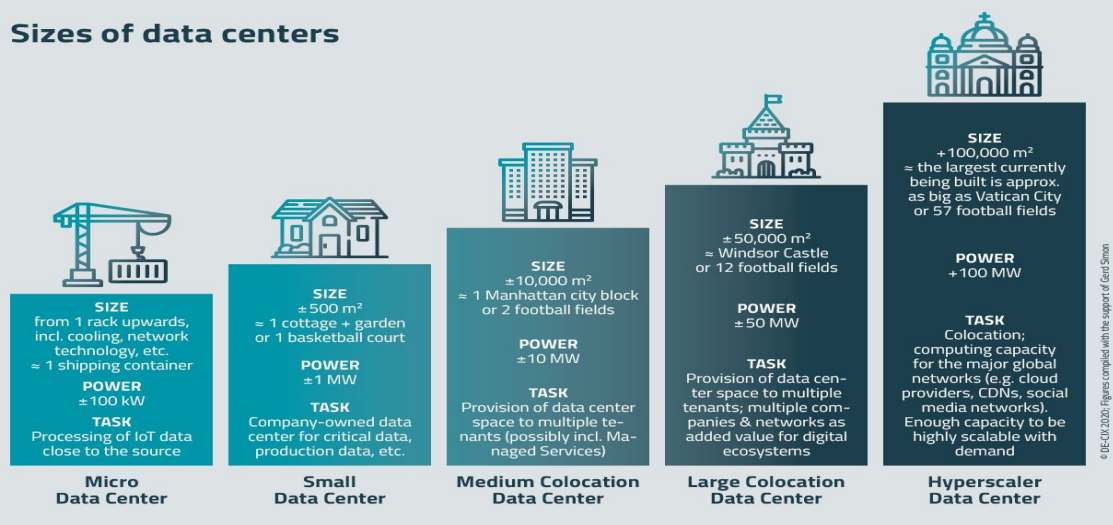
Fog computing performs better than cloud computing in meeting the demands of the emerging paradigms. But of course, it cannot totally replace cloud computing as it will still be preferred for high end batch processing jobs that are very common in the business world. Hence, we can come to the conclusion that fog computing and cloud computing will complement each other while having their own advantages and disadvantages. Studies related to security, confidentiality and system reliability in the fog computing platform is absolutely a topic for research and has to be discovered. Fog computing will grow in helping the emerging network paradigms that require faster processing with less delay and delay jitter, cloud computing would serve the business community meeting their high end computing demands lowering the cost based on a utility pricing model.

# The Role of the Data Center

Data centers are an integral part of the enterprise, designed to support business applications and provide services such as:

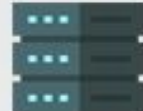
- Data storage, management, backup and recovery
- Productivity applications, such as email
- High-volume e-commerce transactions
- Powering online gaming communities
- Big data, machine learning and artificial intelligence

## Sizes of data centers





Software



Servers



Storage



Networking



infrastructure



Environment  
Monitoring



Cabling



Backup  
Power



Cooling





## Resources:



THANK YOU

[https://www.google.com/search?sca\\_esv=567513126&sxsrf=AM9HkKkoxsNgzdbWsWgDlnl4dYPGSB\\_nVA:1695362746209&q=Cloud+and+fog+computing+applications&tbm=vid&source=lnms&sa=X&ved=2ahUKEwjayoKyxr2BAxVJTWwGHeUDBEoQ0pQJegQIUxAB&biw=1280&bih=571&dpr=1.5#fpstate=ive&vld=cid:2a55b4c1,vid:epROHm2IMGo,st:0](https://www.google.com/search?sca_esv=567513126&sxsrf=AM9HkKkoxsNgzdbWsWgDlnl4dYPGSB_nVA:1695362746209&q=Cloud+and+fog+computing+applications&tbm=vid&source=lnms&sa=X&ved=2ahUKEwjayoKyxr2BAxVJTWwGHeUDBEoQ0pQJegQIUxAB&biw=1280&bih=571&dpr=1.5#fpstate=ive&vld=cid:2a55b4c1,vid:epROHm2IMGo,st:0)