Unit-1

Introduction

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- Disadvantages of Cloud Computing
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Why Cloud computing?

Developing in the cloud enables users to get their applications to market quickly. Hardware failures do not result in data loss because of networked backups. Cloud computing uses remote resources, saving organizations the cost of servers and other equipment.

What is Cloud Computing?

Cloud Computing Definition

Cloud Definition: The cloud in cloud computing provides the means through which everything — from computing power to computing infrastructure, applications, business processes to personal collaboration — can be delivered to a user as a service wherever and whenever the user needs. The cloud itself is a set of hardware, networks, storage, services, and interfaces that enable the delivery of computing as a service. Cloud services include the delivery of software,

infrastructure, and storage over the Internet (either as separate components or a complete platform) based on user demand.

Other Definition of cloud computing

Cloud computing is a model for enabling ubiquitous, 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. Cloud computing refers to both the applications delivered as services over the Internet and the hardware and system software in the datacenters that provide those services.

The cloud embodies the following basic characteristics:

- Elasticity and the ability to scale up and down
- Self-service provisioning and automatic de-provisioning
- Application programming interfaces (APIs)
- Billing and metering of service usage in a pay-as-you-go model
- Security

Elasticity and scalability

The service provider can‘t anticipate how customers will use the service. One customer might use the service three times a year during peak selling seasons, whereas another might use it as a primary development platform for all of its applications. Therefore, the service needs to be available all the time (7 days a week, 24 hours a day) and it has to be designed to scale upward for high periods of demand and downward for lighter ones. Scalability also means that an application can scale when additional users are added and when the application requirements change. This ability to scale is achieved by providing elasticity.

Self-service provisioning

Customers can easily get cloud services without going through a lengthy process. The customer simply requests an amount of computing, storage, software, process, or other resources from the service provider. While the on-demand provisioning capabilities of cloud services eliminate many time delays, an organization still needs to do its homework. These services aren‘t free; needs and requirements must be determined before capability is automatically provisioned.

Application programming interfaces (APIs)

Cloud services need to have standardized APIs. These interfaces provide the instructions on how two application or data sources can communicate with each other. A standardized interface lets the customer more easily link a cloud service, such as a customer relationship management system with a financial accounts management system, without having to resort to custom programming.

Billing and metering of services

A cloud environment needs a built-in service that bills customers. And, of course, to calculate that bill, usage has to be metered (tracked). Even free cloud services (such as Google‘s Gmail or Zoho‘s Internet-based office applications) are metered. In addition to these characteristics, cloud computing must have two overarching requirements to be effective:

- A comprehensive approach to service management
- A well-defined process for security management

Performance monitoring and measuring

A cloud service provider must include a service management environment. A service management environment is an integrated approach for managing the physical environments and IT systems. This environment must be able to maintain the required service level for that organization. In other words, service management has to monitor and optimize the service or sets of services. Service management has to consider key issues, such as performance of the overall system, including security and performance. For example, an organization using an internal or external email cloud service would require 99.999 percent uptime with maximum security. The organization would expect the cloud provider to prove that it has met its obligations.

Many cloud service providers give customers a dashboard — a visualization of key service metrics — so they can monitor the level of service they‘re getting from their provider. Also, many customers use their own monitoring tools to determine whether their service level requirements are being met.

Security

Many customers must take a leap of faith to trust that the cloud service is safe. Turning over critical data or application infrastructure to a cloud-based service provider requires making sure that the information can‘t be accidentally accessed by another company (or maliciously accessed by a hacker). Many companies have compliance requirements for securing both internal and external information. Without the right level of security, one might not be able to use a provider‘s offerings.

- **Cloud computing has mainly five characteristics**:

1. **On-demand self-service**, the services are available on demand, the user can get the services at any time, all it takes is an Internet connection.
2. **Broad network access**, the cloud is accessed remotely over the network, while the access to the cloud is through the internet; it means that it is accessible to its computing capabilities, software, and hardware from anywhere.
3. **Resources pooling** in an independent location and resources serve a large number of users with all their different devices and their required resources.
4. **Rapid elasticity**, dealing with the cloud is very easy, the user can simply reduce or increase the capacity, and also it’s faster than the regular computing types.
5. **Measured Service**, the cloud systems control and reuse the resources by using measurement capabilities and according to the type of service, these services also have financial return, depending on usage.

Applications:

- Email
  - Gmail, Yahoo mail
- Online Collaboration tools
  - Google docs for collaboration on documents
  - Google Hangouts for video conferencing

- Big Data Analytics
  - Provides a cost effective and scalable infrastructure to support big data and business analytics.
- Test and Development
  - now readily available environments tailored for your needs at your fingertips.
- Storage

Advantages of Cloud Computing

- Lower computer costs
- Instant software updates
- Unlimited storage capacity
- Increased data reliability
- Universal document access
- Device independence
- Lowers the outlay expense for start up companies
- Easier group collaboration

Disadvantages of Cloud Computing

- Requires a constant Internet connection
- Does not work well with low-speed connections
- Governance and Regulatory compliance
  - Not all service providers have well-defined service-level agreements.
- Stored data might not be secure:
  - Limited knowledge of the physical location of stored data
  - Multi-tenant platform
  - Limited capabilities for monitoring access to

applications hosted on cloud.

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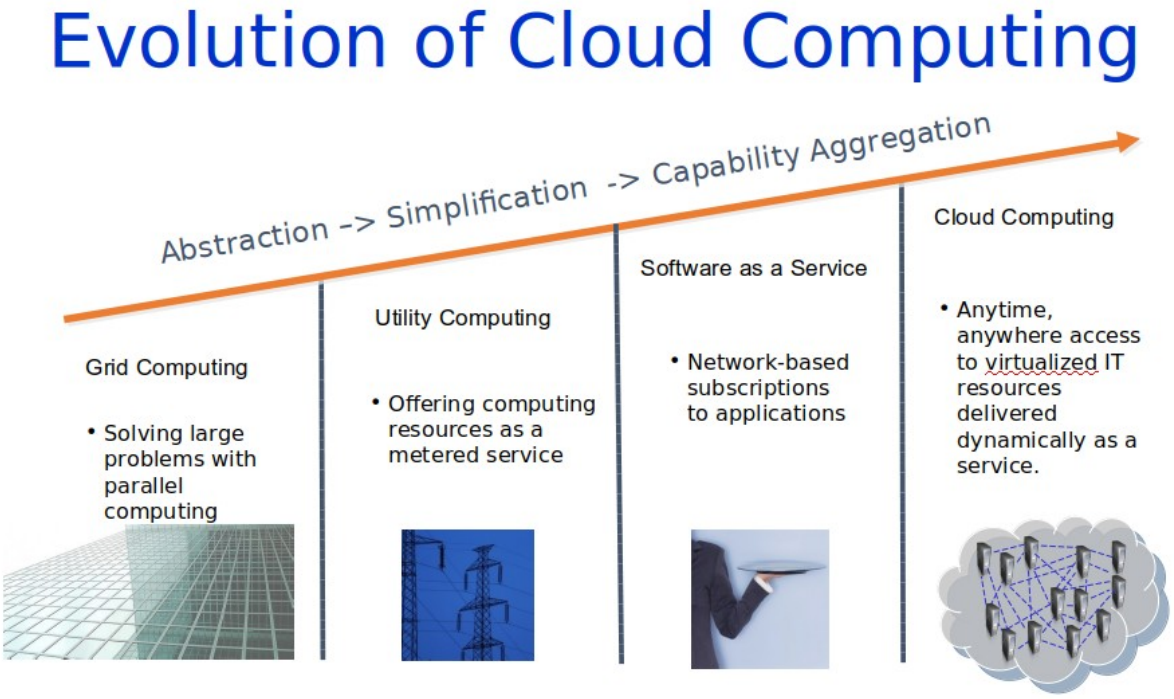
5 Real-World Examples of Cloud Computing

- Ex: Dropbox, Gmail, Facebook.
- Ex: Maropost for Marketing, Hubspot, Adobe Marketing Cloud.
- Ex: SlideRocket, Ratatype, Amazon Web Services.
- Ex: ClearDATA, Dell's Secure Healthcare Cloud, IBM Cloud.
- Uses: IT consolidation, shared services, citizen services

EVOLUTION OF CLOUD COMPUTING AND BASIC TERMINOLOGIES



Cluster Computing

Cluster computing it's a group of computers connected to each other and work together as a single computer. These computers are often linked through a LAN.

The cluster is a tightly coupled systems, and from its characteristics that it's a centralized job management and scheduling system.

All the computers in the cluster use the same hardware and operating system, and the computers are the same physical location and connected with a very high speed connection to perform as a single computer.

The resources of the cluster are managed by centralized resource manager.
Architecture: The architecture of cluster computing contains some main components and they are:

1. Multiple stand alone computers.

2. Operating system.

3. High performance interconnects.

4. Communication software.

5. Different applications

Advantages:

software is automatically installed and configured, and the nodes of the cluster can be added and managed easily, so it's very easy to deploy, it's an open system, and very cost effective to acquire and manage, clusters have many sources of support and supply, it's fast and very flexible, the system is optimized for performance as well as simplicity and it can change software configurations at any time, also it saves the time of searching the net for latest drivers, The cluster system is very supportive as it includes software updates.

Disadvantages

it's hard to be managed without experience, also when the size of cluster is large, it'll be difficult to find out something has failed, the programming environment is hard to be improved when software on some node is different from the other.

Grid Computing

Grid computing is a combination of resources from multiple administrative domains to reach a common target, and this group of computers can distributed on several location and each a group of grids can be connected to each other.

The computers in the grid are not required to be in the same physical location and can be operated independently, so each computer on the grid is concerned a distinct computer.

The computers in the grid are not tied to only on operating system and can run different OSs and different hardware, when it comes to a large project, the grid divides it to multiple computers to easily use their resources.

Architecture:

Fabric layer to provide the resources which shared access is mediated by grid computing.

Connectivity layer and it means the core communication and authentication protocols required for grid specific network functions.

Resource layer and it defines the protocols, APIs and SDK for secure negotiations, imitations, monitoring control, accounting and payment of sharing operations on individual resources.

Collective layer which it contains protocols and services that capture interactions among a collection of resources

Application layer, it’s user applications that operate within environment.

Advantages:

One of the advantages of grid computing that you don’t need to buy large servers for applications that can be split up and farmed out to smaller commodity type servers,

secondly it’s more efficient in use of resources.

Also the grid environments are much more modular and don't have much points of failure.

About policies in the grid it can be managed by the grid software, beside that upgrading can be done without scheduling downtime, and jobs can be executed in parallel speeding performance.

Disadvantages:

It needs fast interconnect between computers resources,

some applications may need to be pushed to take full advantage of the new model,

licensing across many servers may make it forbidden for some applications,

the grid environments include many smaller servers across various administrative domains. also political challenges associated with sharing resources especially across different admin domains.

Utility Computing

Utility Computing refers to a type of computing technologies and business models which provide services and computing resources to the customers, such as storage, applications and computing power.

This repackaging of computing services is the foundation of the shift to on demand computing, software as a service and cloud computing models which late developed the idea of computing, applications and network as a service.

Utility computing is kind of virtualization, that means the whole web storage space and computing power which it’s available to users is much larger than the single time-sharing computer.

Multiple backend web servers used to make this kind of web service possible.

Utility computing is similar to cloud computing and it often requires a cloud-like infrastructure.

Advantages:

the client doesn't have to buy all the hardware, software and licenses needed to do business. Instead, the client relies on another party to provide these services.

It also gives companies the option to subscribe to a single service and use the same suite of software throughout the entire client organization.

it offers compatibility of all the computers in large companies.

Disadvantages:

The service could be stopped from the utility computing company for any reason such as a financial trouble or equipment problems.

Also utility computing systems can also be attractive targets for hackers, and much of the responsibility of keeping the system safe falls to the provider

Cloud Computing

Cloud computing is a term used when we are not talking about local devices which it does all the hard work when you run an application, but the term used when we're talking about all the devices that run remotely on a network owned by another company which it would provide all the possible services from e-mail to complex data analysis programs.

This method will decrease the users' demands for software and super hardware.

The only thing the user will need is running the cloud computing system software on any device that can access to the Internet

cloud and utility computing often conjoined together as a same concept but the difference between them is that

utility computing relates to the business model in which application infrastructure resources are delivered, whether these resources are hardware, software or both.

While cloud computing relates to the way of design, build, and run applications that work in a virtualization environment, sharing resources and boasting the ability grow dynamically, shrink and the ability of self healing.

computing type	Characteristics	Advantages	Disadvantage	Comments	S/W and H/W
Cluster	1. Tightly coupled systems 2. Single system image 3. Centralized Job management & scheduling system	1. Easy to deploy 2.Complete 3.Open 4.Easy to manage 5.Flexible 6.Optimized 7.Expandable 8.Supported	1. no need to experience 2. difficult to find failure 3.Programming is hard to be improved when software is different between the nodes.	In cluster computing, a bunch of similar (or identical) computers are hooked up locally (in the same physical location, directly connected with very high speed connections) to operate as a single computer	The cluster computers all have the same hardware and OS.
Grid	1. Loosely coupled 2. Diversity and Dynamism 3. Distributed Job Management & scheduling	1. No need to buy large servers for applications 2. More efficient use of idle resources. 3. Its environments are more modular and don't have much points of failure. 4.Policies can be managed by the grid software. 5.Upgrading can be done without scheduling downtime. 6.Jobs can be executed in parallel speeding	1. Needs a fast interconnect. 2. Some applications don't take full advantage of the new models. 3. No licensing across many servers for some applications. 4. Includes many smaller servers across various administrative domains.	In grid computing, the computers do not have to be in the same physical location and can be operated independently. As far as other computers are concerned each computer on the grid is a distinct computer.	The computers that are part of a grid can run different operating systems and have different hardware
Utility	1. Scalability. 2. Demand pricing. 3. Standardized Utility Computing Services. 4. Share the web and other resources in the shared pool of machines. 5. Automation.[	1. Lower computer costs. 2. Subscription of a single service with the same suite of software. 3. Compatibility. 4. Unlimited storage capacity.	1. Needs a fast interconnect. 2. Some applications don't take full advantage of the new models. 3. No licensing across many servers for some applications. 4. Includes many smaller servers across various administrative domains. 5. Political challenges.	In utility computing, the computers need not to be in the same physical location.	The memory, storage devices and net work communications are managed by the OS of the basic physical cloud units
Cloud	1.On-demand self-service. 2. Broad network access. 3.Resources pooling 4. Rapid elasticity 5.Measured Service.[8]	1. Lower computer costs. 2. Improved performance. 3. Reduced software costs. 4. Instant software updates 5.Improved document format compatibility 6.Unlimited storage capacity, 7. Increased data reliability, 8.Universal document access, 9.Latest version availability of your documents, 10.Easier group collaboration, 11. You are no longer connected to a single computer.	1. Requires a constant internet connection. 2. Does not work well with low-speed connections. 3. Can be slow, Even with a fast connection 5. Stored data might not be secure 6. if the cloud destroyed you can't backup your data.[7]	In cloud computing, the computers need not to be in the same physical location.	The memory, storage device and network communication are managed by the operating system of the basic physical cloud units.

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Underlying principles of parallel & distributed computing

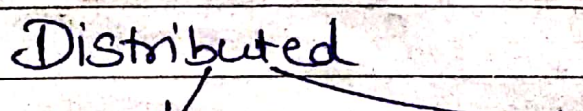
→ Parallel V/s distributed computing

→ Cloud V/s Cluster V/s grid V/s Utility

Distributed Computing

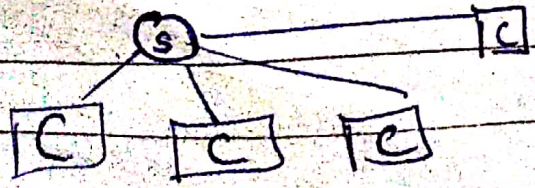
- Network of autonomous computers communicate with each other to achieve a goal
- Computer in distributed System are independent and don't physically share memory or processors
- Communicate with each other via message passing

Computer in distributed System can have different roles based on goals of System & Computer's own hardware and Software properties



Client / Server

- Centeralized
- Single server provides services to many clients



Peer to peer

- Decentralized
- all are equally responsible; no main server
- all contributes some processing power and memory

Features of Distributed Computing

(1) – Modularity

→ Two architecture
- Peer to peer
- client server

are designed to enforce modularity

→ Its is an idea the the components of the system should be black box to each other.

→ It doesn't worry about how the implementation is going to happen as it interacts via interface that throws the output via input

(2) – Message passing

In distributed system each system communicate with each other via message passing. Consist of three essential parts :–
- Sender
- Recipient
- Content

Message protocals is a set of encoding & decoding. They have a particular format

Parallel Computing

- usage of multiple processors
- If two or more processors are available many tasks can be done more quickly.
- While one is doing one aspect of some computation, other is doing some other aspect of computation.
- In order to be able to work together, multiple processor need to share information with each other This is done using shared memory environment

Variables
data structures
Objects

] In that enviroment is accessable by all the processors

Arch·Red

Cloud Computing Business Models

Karri Huhtanen

16th of November 2010

Arch·Red

Positioning the Players

Cloud Technology Providers	Infrastructure as a Service	Platform as a Service	Software as a Service
	HP	Google App Engine	Cordys
	IBM	Facebook	Zynga
	RackSpace	Force.Com	SalesForce
	OpenStack	Microsoft Azure	
	Eucalyptus		Dropbox
	VMWare	Amazon Web Services	Animoto
	Oracle		Arch Red
	Techila		

Cloud Technology Providers

- Hardware, software and services for building private and public clouds
- Products based on the components needed for example for large-scale virtualisation, data storage, databases etc.
- Some of the products based on the in-house solutions for building clouds before the cloud was called cloud (Rackspace => OpenStack)
- Some deliberately designed for this purpose (Eucalyptus), business model open source with commercial support services, OEM branding (HP)
- Grid computing platform (Techila)
- Also complete (private) cloud implementations offered as a infrastructure service (HP, IBM, Rackspace)

Infrastructure as a Service (IaaS)

- At the simplest only data center or virtualisation services rebranded.
- Competitive advantage usually based on the more efficient utilisation of existing infrastructure and position (excess capacity, datacenters, economies of scale (software, hardware, Internet etc.))
- Products and services developed from the infrastructure building and management solutions (for example Amazon Web Services (IaaS provider) ⇔ Amazon.com (customer))
- Packaged to be easy to buy, utilise and deploy
- Charging based on the resources and services used (time, bandwidth, transactions, storage etc.) Custom units and different measure methods make the comparison of the provider prices harder.

Platform as a Service (PaaS)

- Adds a layer of abstraction over actual infrastructure (key asset of the PaaS provider)
- Sandboxed, more locked-in access to interfaces and resources – but also more tasks handled by provider (automation, load balancing, billing etc.)
- Services build on the platform promoted in the PaaS providers store (e.g. Google Apps Marketplace) => PaaS revenue from both providing resources and helping to bill/sell services
- More data to be analysed or mined (Facebook, Google, if not all)
- PaaS customers can be also sources of innovation and targets for acquirement => it is easy to integrate services, which already utilise the same platform
- Some PaaS (Force.com) developed also from the SaaS (SalesForce.com) using the already build datacenters and infrastructure.

Software as a Service (SaaS)

- The utilisers of IaaS and PaaS
- As many business models as there are companies
- Even more reasons to utilise: scaling, costs, robustness, reliability, latency, promotion, distribution, economies of scale, marketing, exit strategy etc.
- Pricing model depends on the service: subscriptions, pay-per-use, pay-per-seat, freemium model etc.
- Customer value (and charging) > Service production costs
- Customer charges must cover the risks of service disruption and possible service level agreement (SLA) compensations.

Additional Models

- Building management systems, for example Canonical Landscape, Ubuntu Enterprise Cloud
- Cloud Management Platform, for example Rightscale, scaling, deploying and connecting cloud services
- Integrating existing software to ready-to-use cloud images, charging for subscription or support
- Developing cloud services or migrating services to cloud: e.g. Codento, Vincit, Arch Red etc.

Arch·Red

Summary

Author's recommendation for market entry

Cl… Technology Providers	Infrastructure as a Service	Platform as a Service	Softwa… Service
	HP	Google App Engine	Rightscale
	IBM	Facebook	Cordys
	RackSpace	Force.Com	SalesForce
	OpenStack	Microsoft Azure	Canonical Landscape
	Eucalyptus	Amazon Web Services	Dropbox
	VMWare		Animoto
	Oracle		Arch Red
	Techila		

Vendor lock-in tightens, but opportunities for innovation, business models and market entry increase, need for venture capital decrease

Market entry costs and capital investment needs increase, need for venture capital increases

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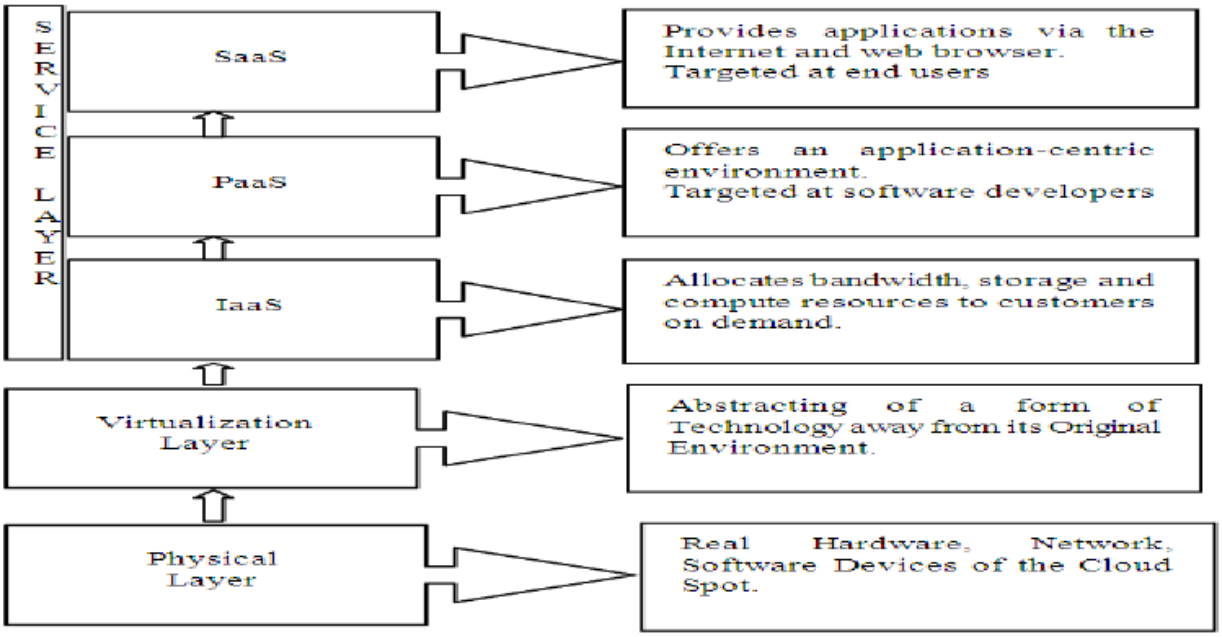
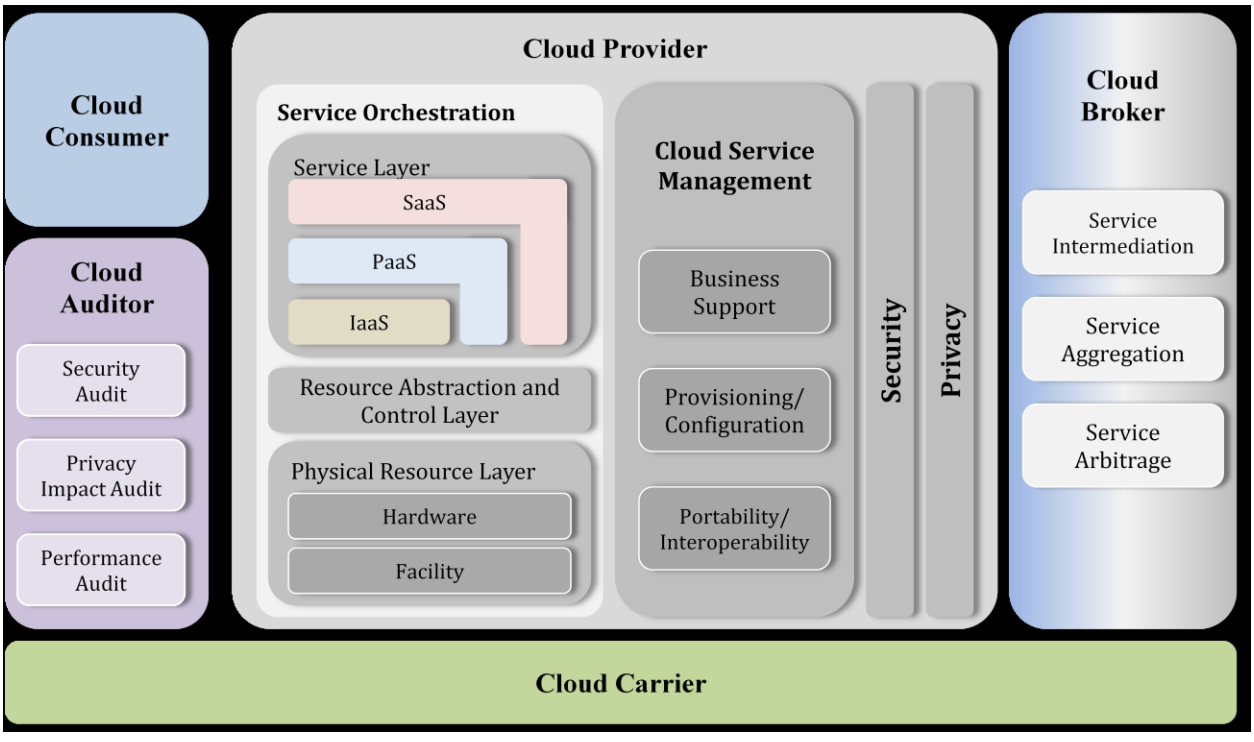
Topic: The Cloud Architecture; Models – Delivery and Deployment

LAYERED CLOUD ARCHITECTURE



NIST CLOUD REFERENCE ARCHITECTURE



This Figure presents an overview of the NIST cloud computing reference architecture, which identifies the major actors, their activities and functions in cloud computing. The diagram depicts a generic high-level architecture and is intended to facilitate the understanding of the requirements, uses, characteristics and standards of cloud computing. NIST cloud computing reference architecture defines five major actors: *cloud consumer, cloud provider, cloud carrier, cloud auditor* and *cloud broker*

Actor	Definition
Cloud Consumer	A person or organization that maintains a business relationship with, and uses service from, *Cloud Providers*.
Cloud Provider	A person, organization, or entity responsible for making a service available to interested parties.
Cloud Auditor	A party that can conduct independent assessment of cloud services, information system operations, performance and security of the cloud implementation.
Cloud Broker	An entity that manages the use, performance and delivery of cloud services, and negotiates relationships between *Cloud Providers* and *Cloud Consumers*.
Cloud Carrier	An intermediary that provides connectivity and transport of cloud services from *Cloud Providers* to *Cloud Consumers*.

Cloud Consumer

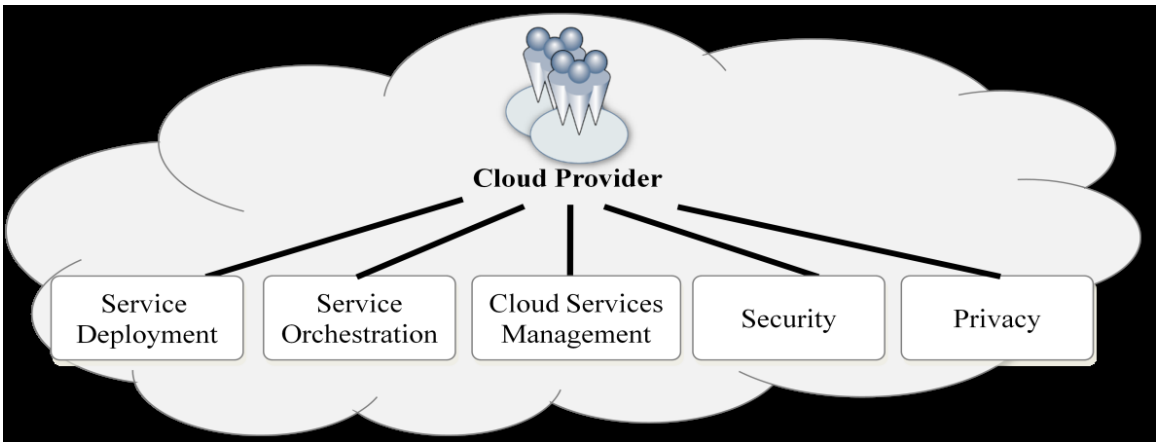
The cloud consumer is the principal stakeholder for the cloud computing service. A cloud consumer represents a person or organization that maintains a business relationship with, and uses the service from a cloud provider. A cloud consumer browses the service catalog from a cloud provider, requests the appropriate service, sets up service contracts with the cloud provider, and uses the service. The cloud consumer may be billed for the service provisioned, and needs to arrange payments accordingly.

Cloud consumers need SLAs to specify the technical performance requirements fulfilled by a cloud provider. SLAs can cover terms regarding the quality of service, security, remedies for performance failures. A cloud provider may also list in the SLAs a set of promises explicitly not made to consumers, i.e. limitations, and obligations that cloud consumers must accept. A cloud consumer can freely choose a cloud provider with better pricing and more favorable terms. Typically a cloud provider's pricing policy and SLAs are non-negotiable, unless the customer expects heavy usage and might be able to negotiate for better contracts.

Cloud Provider

A cloud provider is a person, an organization; it is the entity responsible for making a service available to interested parties. A Cloud Provider acquires and manages the computing infrastructure required for providing the services, runs the cloud software that provides the services, and makes arrangement to deliver the cloud services to the Cloud Consumers through network access.

For Software as a Service, the cloud provider deploys, configures, maintains and updates the operation of the software applications on a cloud infrastructure so that the services are provisioned at the expected service levels to cloud consumers. The provider of SaaS assumes most of the responsibilities in managing and controlling the applications and the infrastructure, while the cloud consumers have limited administrative control of the applications.



Cloud Auditor

A cloud auditor is a party that can perform an independent examination of cloud service controls with the intent to express an opinion thereon. Audits are performed to verify conformance to standards through review of objective evidence. A cloud auditor can evaluate the services provided by a cloud provider in terms of security controls, privacy impact, performance, etc.

A privacy impact audit can help Federal agencies comply with applicable privacy laws and regulations governing an individual‟s privacy, and to ensure confidentiality, integrity, and availability of an individual‟s personal information at every stage of development and operation.

Cloud Broker

As cloud computing evolves, the integration of cloud services can be too complex for cloud consumers to manage. A cloud consumer may request cloud services from a cloud broker, instead of contacting a cloud provider directly. A cloud broker is an entity that manages the use, performance and delivery of cloud services and negotiates relationships between cloud providers and cloud consumers.

In general, a cloud broker can provide services in three categories :

Service Intermediation: A cloud broker enhances a given service by improving some specific capability and providing value-added services to cloud consumers. The improvement can be managing access to cloud services, identity management, performance reporting, enhanced security, etc.

Service Aggregation: A cloud broker combines and integrates multiple services into one or more new services. The broker provides data integration and ensures the secure data movement between the cloud consumer and multiple cloud providers.

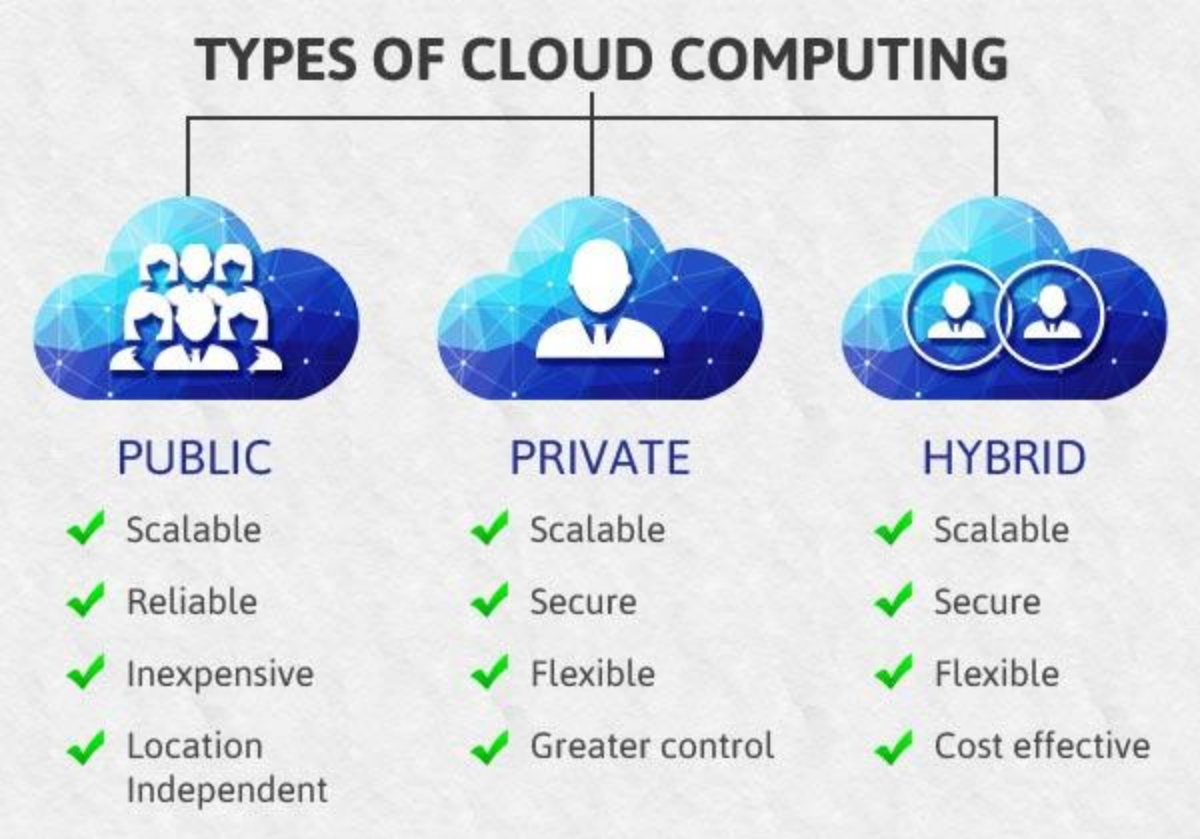
Service Arbitrage: Service arbitrage is similar to service aggregation except that the services being aggregated are not fixed. Service arbitrage means a broker has the flexibility to choose services from multiple agencies. The cloud broker, for example, can use a credit-scoring service to measure and select an agency with the best score.

Cloud Carrier

A cloud carrier acts as an intermediary that provides connectivity and transport of cloud services between cloud consumers and cloud providers. Cloud carriers provide access to consumers through network, telecommunication and other access devices. For example, cloud consumers can obtain cloud services through network access devices, such as computers, laptops, mobile phones, mobile Internet devices (MIDs), etc [1]. The distribution of cloud services is normally provided by network and telecommunication carriers or a transport agent, where a transport agent refers to a business organization that provides physical transport of storage media such as high-capacity hard drives. Note that a cloud provider will set up SLAs with a cloud carrier to provide services consistent with the level of SLAs offered to cloud consumers, and may require the cloud carrier to provide dedicated and secure connections between cloud consumers and cloud providers.

Deployment Models: PUBLIC PRIVATE HYBRID CLOUD

Difference	Private	Public	Hybrid
Tenancy	Single tenancy: there's only the data of a single organization stored in the cloud.	Multi-tenancy: the data of multiple organizations in stored in a shared environment.	The data stored in the public cloud is usually multi-tenant, which means the data from multiple organizations is stored in a shared environment. The data stored in private cloud is kept private by the organization.
Exposed to the Public	No: only the organization itself can use the private cloud services.	Yes: anyone can use the public cloud services.	The services running on a private cloud can be accessed only the organization's users, while the services running on public cloud can be accessed by anyone.
Data Center Location	Inside the organization's network.	Anywhere on the Internet where the cloud service provider's services are located.	Inside the organization's network for private cloud services as well as anywhere on the Internet for public cloud services.
Cloud Service Management	The organization must have their own administrators managing their private cloud services.	The cloud service provider manages the services, where the organization merely uses them.	The organization itself must manage the private cloud, while the public cloud is managed by the CSP.
Hardware Components	Must be provided by the organization itself, which has to buy physical servers to build the private cloud on.	The CSP provides all the hardware and ensures it's working at all times.	The organization must provide hardware for the private cloud, while the hardware of CSP is used for public cloud services.
Expenses	Can be quite expensive, since the hardware, applications and network have to be provided and managed by the organization itself.	The CSP has to provide the hardware, set-up the application and provide the network accessibility according to the SLA.	The private cloud services must be provided by the organization, including the hardware, applications and network, while the CSP manages the public cloud services.



What is Public Cloud Computing?

A cloud platform that is based on standard cloud computing model in which service provider offers resources, applications storage to the customers over the internet is called as public cloud computing. The hardware resources in public cloud are shared among similar users and accessible over a public network such as the internet. Most of the applications that are offered over internet such as Software as a Service (SaaS) offerings such as cloud storage and online applications uses Public Cloud Computing platform. Budget conscious startups, SMEs not keen on high level of security features looking to save money can opt for Public Cloud Computing.

Advantage of Public Cloud Computing

1. It offers greater scalability
2. Its cost effectiveness helps you save money.
3. It offers reliability which means no single point of failure will interrupt your service.
4. Services like SaaS, (Paas), (Iaas) are easily available on Public Cloud platform as it can be accessed from anywhere through any Internet enabled devices.
5. It is location independent – the services are available wherever the client is located.

Disadvantage of Public Cloud Computing

1. No control over privacy or security
2. Cannot be used for use of sensitive applications
3. Lacks complete flexibility as the platform depends on the platform provider
4. No stringent protocols regarding data management

What is Private Cloud Computing?

A cloud platform in which a secure cloud based environment with dedicated storage and hardware resources provided to a single organization is called Private Cloud Computing. The Private cloud can be either hosted within the company or outsourced to a trusted and reliable third-party vendor. It offers company a greater control over privacy and data security. The resources in case of private cloud are not shared with others and hence it offer better performance compared to public cloud. The additional layers of security allow company to process confidential data and sensitive work in the private cloud environment.

Advantage of Private Cloud Computing

1. Offers greater Security and Privacy
2. Offers more control over system configuration as per the company's need
3. Greater reliability when it comes to performance
4. Enhances the quality of service offered by the clients
5. Saves money

Disadvantage of Private Cloud

1. Expensive when compared to public cloud
2. Requires IT Expertise

What is Hybrid Cloud Computing?

Hybrid Cloud computing allows you to use combination of both public and private cloud. This helps companies to maximize their efficiency and deliver better performance to clients. In this model companies can use public cloud for transfer of non-confidential data and switch on to private cloud in case of sensitive data transfer or hosting of critical applications. This model is gaining prominence in many business as it gives benefits of both the model.

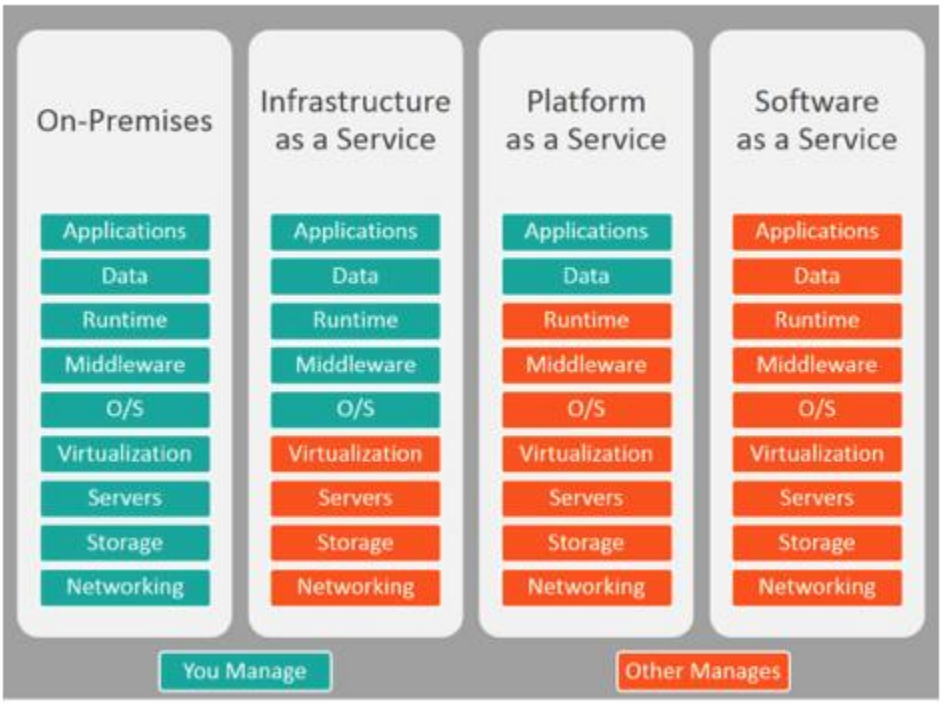
Advantage of Hybrid Cloud Computing

1. It is scalable
2. It is cost efficient
3. Offers better security
4. Offers greater flexibility

Disadvantage of Hybrid Cloud Computing

1. Infrastructure Dependency
2. Possibility of security breach through public cloud

Delivery Models: IAAS, PAAS & SAAS



IaaS: Infrastructure as a Service

This is a virtual equivalent of a traditional data center. Cloud infrastructure providers use virtualization technology to deliver scalable compute resources such as server s, network s and storage to their clients. This is beneficial for the clients, as they don't have to buy personal hardware and manage its component s. Instead, they can deploy their platforms and application s within the provider's virtual machines that offer the same technologies and capabilities as a physical data center.

An IaaS provider is responsible for the entire infrastructure, but users have total control over it. In turn, users are responsible for installing and maintaining apps and operating systems, as well as for security, runtime, middleware and data.

IaaS users can compare the cost and performance of different providers in order to choose the best option, as they can access them through a single API.

IaaS Key Features

- Highly scalable resources
- Enterprise-grade infrastructure
- Cost depends on consumption
- Multitenant architecture, i.e. a single piece of hardware serves many users
- The client gets complete control over the infrastructure

IaaS Advantages

- The most flexible and dynamic model
- Cost-effective due to pay-as-you-go pricing

- Easy to use due to the automate d deployment of hardware
- Management tasks are virtualized, so employees have more free time for other tasks

IaaS Disadvantages

- Data security issues due to multitenant architecture
- Vendor outages make customers unable to access their data for a while
- The need for team training to learn how to manage new infrastructure

When to Use IaaS

IaaS can be especially advantageous in some situations:

- If you are a small company or a startup that has no budget for creating your own infrastructure
- If you are a rapidly growing company and your demands are unstable and changeable
- If you are a large company that wants to have effective control over infrastructure but pay only for the resources you actually use

Examples of IaaS

The best-known IaaS solution s vendors are Microsoft Azure, Google Compute Engine (GCE), Amazon Web Services (AWS), Cisco Metapod, DigitalOcean, Linode and Rackspace.

PaaS: Platform as a Service

PaaS in cloud computing is a framework for software creation delivered over the internet. This is the offering of a platform with built-in software components and tools, using which developer s can create, customize, test and launch applications. PaaS vendors manage servers, operating system updates, security patches and backups. Clients focus on app development and data without worrying about infrastructure, middleware and OS maintenance.

The main difference between IaaS and PaaS lies in the degree of control given to users.

PaaS Key Features

- Allows for developing, testing and hosting apps in the same environment
- Resources can be scaled up and down depending on business needs
- Multiple users can access the same app in development
- The user doesn’t have complete control over the infrastructure
- Web services and databases are integrated
- Remote teams can collaborate easily

PaaS Advantages

- PaaS-built software is highly scalable, available and multi-tenant, as it is cloud-based
- The development process is quickened and simplified
- Reduced expenses for creating, testing and launching apps
- Automated company policy
- Reduced amount of coding required
- Allows for easy migrating to the hybrid cloud

PaaS Disadvantages

- Data security issues
- Compatibility of existing infrastructure (not every element can be cloud-enabled)
- Dependency on vendor's speed, reliability and support

When to Use PaaS

Such solutions are especially profitable to developers who want to spend more time coding, testing and deploying their applications. Utilizing PaaS is beneficial when:

- Multiple developers work on one project
- Other vendors must be included
- You want to create your own customized apps

Examples of PaaS

The best-known PaaS solutions vendors are Google App Engine, Amazon AWS, Windows Azure Cloud Services, Heroku, AWS Elastic Beanstalk, Apache Stratos and OpenShift.

SaaS: Software as a Service

With this offering, users get access to the vendor's cloud-based software. Users don't have to download and install SaaS applications on local devices, but sometimes they may need plugins. SaaS software resides on a remote cloud network and can be accessed through the web or APIs. Using such apps, customers can collaborate on projects, as well as store and analyze data.

SaaS is the most common category of cloud computing. The SaaS provider manages everything from hardware stability to app functioning. Clients are not responsible for anything in this model; they only use programs to complete their tasks. In this case, the client software experience is fully dependent on the provider.

SaaS Key Features

- The subscription model of utilizing
- No need to download, install or upgrade software
- Resources can be scaled depending on requirements
- Apps are accessible from any connected device
- The provider is responsible for everything

SaaS Advantages

- No hardware costs
- No initial setup costs
- Automated upgrades
- Cross-device compatibility
- Accessible from any location
- Pay-as-you-go model
- Scalability
- Easy customization

SaaS Disadvantages

- Loss of control
- Limited range of solutions
- Connectivity is a must

When to Use SaaS

Utilizing SaaS is most beneficial in the following situations:

- If your company needs to launch a ready-made software quickly
- For short-term projects that require collaboration
- If you use applications on a temporary basis
- For applications that need both web and mobile access

Examples of SaaS

The best-known SaaS solutions vendors are Google Apps, Dropbox, Gmail, Salesforce, Cisco WebEx, Concur, GoToMeeting, Office365.

Difference between Parallel Computing and Distributed Computing

There are mainly two computation types, including ***parallel computing*** and ***distributed computing*.** A computer system may perform tasks according to human instructions. A single processor executes only one task in the computer system, which is not an effective way. Parallel computing solves this problem by allowing numerous processors to accomplish tasks simultaneously. Modern computers support parallel processing to improve system performance. In contrast, distributed computing enables several computers to communicate with one another and achieve a goal. All of these computers communicate and collaborate over the network. Distributed computing is commonly used by organizations such as ***Facebook*** and ***Google*** that allow people to share resources.

In this article, you will learn about the difference between ***Parallel Computing*** and ***Distributed Computing*.** But before discussing the differences, you must know about parallel computing and distributed computing.

What is Parallel Computing?

It is also known as ***parallel processing*.** It utilizes several processors. Each of the processors completes the tasks that have been allocated to them. In other words, parallel computing involves performing numerous tasks simultaneously. A shared memory or distributed memory system can be used to assist in parallel computing. All CPUs in shared memory systems share the memory. Memory is shared between the processors in distributed memory systems.

Parallel computing provides numerous advantages. Parallel computing helps to increase the CPU utilization and improve the performance because several processors work simultaneously. Moreover, the failure of one CPU has no impact on the other CPUs' functionality. Furthermore, if one processor needs instructions from another, the CPU might cause latency.

Advantages and Disadvantages of Parallel Computing

There are various advantages and disadvantages of parallel computing. Some of the advantages and disadvantages are as follows:

Advantages

1. It saves time and money because many resources working together cut down on time and costs.
2. It may be difficult to resolve larger problems on Serial Computing.
3. You can do many things at once using many computing resources.
4. Parallel computing is much better than serial computing for modeling, simulating, and comprehending complicated real-world events.

Disadvantages

1. The multi-core architectures consume a lot of power.

2. Parallel solutions are more difficult to implement, debug, and prove right due to the complexity of communication and coordination, and they frequently perform worse than their serial equivalents.

What is Distributing Computing?

It comprises several software components that reside on different systems but operate as a single system. A distributed system's computers can be physically close together and linked by a local network or geographically distant and linked by a ***wide area network (WAN).*** A distributed system can be made up of any number of different configurations, such as mainframes, PCs, workstations, and minicomputers. The main aim of distributed computing is to make a network work as a single computer.

There are various benefits of using distributed computing. It enables scalability and makes it simpler to share resources. It also aids in the efficiency of computation processes.

Advantages and Disadvantages of Distributed Computing

There are various advantages and disadvantages of distributed computing. Some of the advantages and disadvantages are as follows:

Advantages

1. It is flexible, making it simple to install, use, and debug new services.
2. In distributed computing, you may add multiple machines as required.
3. If the system crashes on one server, that doesn't affect other servers.
4. A distributed computer system may combine the computational capacity of several computers, making it faster than traditional systems.

Disadvantages

1. Data security and sharing are the main issues in distributed systems due to the features of open systems
2. Because of the distribution across multiple servers, troubleshooting and diagnostics are more challenging.
3. The main disadvantage of distributed computer systems is the lack of software support.

Key differences between the Parallel Computing and Distributed Computing

Here, you will learn the various key differences between parallel computing and distributed computation. Some of the key differences between parallel computing and distributed computing are as follows:

1. Parallel computing is a sort of computation in which various tasks or processes are run at the same time. In contrast, distributed computing is that type of computing in which the components are located on various networked systems that interact and coordinate their actions by passing messages to one another.
2. In parallel computing, processors communicate with another processor via a bus. On the other hand, computer systems in distributed computing connect with one another via a network.
3. Parallel computing takes place on a single computer. In contrast, distributed computing takes place on several computers.
4. Parallel computing aids in improving system performance. On the other hand, distributed computing allows for scalability, resource sharing, and the efficient completion of computation tasks.
5. The computer in parallel computing can have shared or distributed memory. In contrast, every system in distributed computing has its memory.
6. Multiple processors execute multiple tasks simultaneously in parallel computing. In contrast, many computer systems execute tasks simultaneously in distributed computing.

Head-to-head Comparison between the Parallel Computing and Distributed Computing

Features	Parallel Computing	Distributed Computing

Definition	It is a type of computation in which various processes runs simultaneously.	It is that type of computing in which the components are located on various networked systems that interact and coordinate their action by passing messages to one another.
Communication	The processors communicate with one another via a bus.	The computer systems connect wit one another via a network.
Functionality	Several processors execute various tasks simultaneously in parallel computing.	Several computers execute tasks simultaneously.
Number of Computers	It occurs in a single computer system.	It involves various computers.
Memory	The system may have distributed or shared memory.	Each computer system in distributed computing has its own memory.
Usage	It helps to improve the system performance	It allows for scalability, resource sharing, and the efficient completion of computation tasks.

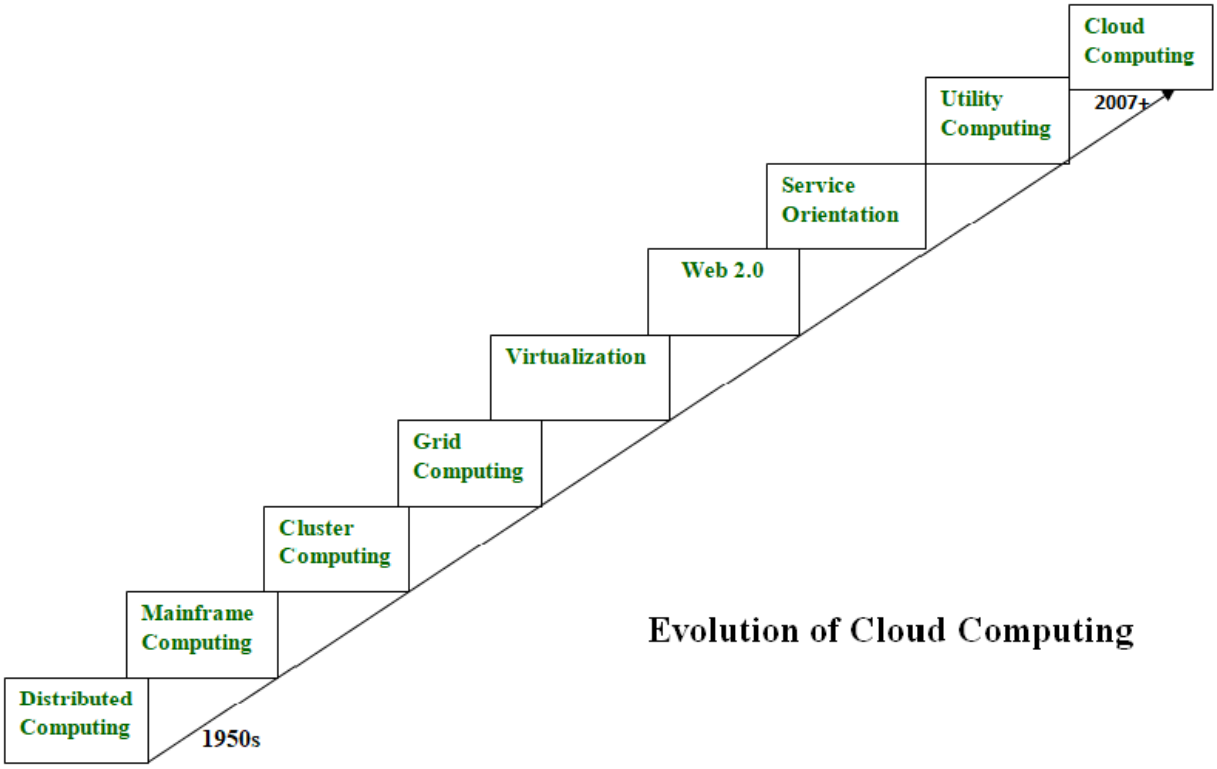
Conclusion

There are two types of computations: parallel computing and distributed computing. Parallel computing allows several processors to accomplish their tasks at the same time. In contrast, distributed computing splits a single task among numerous systems to achieve a common goal.

Cloud computing allows users to access a wide range of services stored in the cloud or on the Internet. **Cloud computing** services include computer resources, data storage, apps, servers, development tools, and **networking protocols**. It is most commonly used by IT companies and for business purposes.

Evolution of Cloud Computing

The phrase "Cloud Computing" was first introduced in the 1950s to describe internet-related services, and it evolved from distributed computing to the modern technology known as **cloud computing**. Cloud services include those provided by Amazon, Google, and Microsoft. Cloud computing allows users to access a wide range of services stored in the cloud or on the Internet. Cloud computing services include computer resources, data storage, apps, servers, development tools, and networking protocols.



Distributed Systems

Distributed System is a composition of multiple independent systems but all of them are depicted as a single entity to the users. The purpose of distributed systems is to share resources and also use them effectively and efficiently. Distributed systems possess characteristics such as scalability, concurrency, continuous availability, heterogeneity, and independence in failures. But the main problem with this system was that all the systems were required to be present at the same geographical location. Thus to solve this problem, distributed computing led to three more types of computing and they were-Mainframe computing, cluster computing, and grid computing.

Mainframe Computing

Mainframes which first came into existence in 1951 are highly powerful and reliable computing machines. These are responsible for handling large data such as massive input-output operations. Even today these are used for bulk processing tasks such as online transactions etc. These systems have almost no downtime with high fault tolerance. After distributed computing, these increased

the processing capabilities of the system. But these were very expensive. To reduce this cost, cluster computing came as an alternative to mainframe technology.

Cluster Computing

In 1980s, cluster computing came as an alternative to mainframe computing. Each machine in the cluster was connected to each other by a network with high bandwidth. These were way cheaper than those mainframe systems. These were equally capable of high computations. Also, new nodes could easily be added to the cluster if it was required. Thus, the problem of the cost was solved to some extent but the problem related to geographical restrictions still pertained. To solve this, the concept of grid computing was introduced.

Grid Computing

In 1990s, the concept of grid computing was introduced. It means that different systems were placed at entirely different geographical locations and these all were connected via the internet. These systems belonged to different organizations and thus the grid consisted of heterogeneous nodes. Although it solved some problems but new problems emerged as the distance between the nodes increased. The main problem which was encountered was the low availability of high bandwidth connectivity and with it other network associated issues. Thus. cloud computing is often referred to as “Successor of grid computing”.

Virtualization

Virtualization was introduced nearly 40 years back. It refers to the process of creating a virtual layer over the hardware which allows the user to run multiple instances simultaneously on the hardware. It is a key technology used in cloud computing. It is the base on which major cloud computing services such as Amazon EC2, VMware vCloud, etc work on. Hardware virtualization is still one of the most common types of virtualization.

Web 2.0

Web 2.0 is the interface through which the cloud computing services interact with the clients. It is because of Web 2.0 that we have interactive and dynamic web pages. It also increases flexibility among web pages. Popular examples of web 2.0 include Google Maps, Facebook, Twitter, etc. Needless to say, social media is possible because of this technology only. It gained major popularity in 2004.

Service Orientation

A service orientation acts as a reference model for cloud computing. It supports low-cost, flexible, and evolvable applications. Two important concepts were introduced in this computing model. These were Quality of Service (QoS) which also includes the SLA (Service Level Agreement) and Software as a Service (SaaS).

Utility Computing

Utility Computing is a computing model that defines service provisioning techniques for services such as compute services along with other major services such as storage, infrastructure, etc which are provisioned on a pay-per-use basis.

Cloud Computing

Cloud Computing means storing and accessing the data and programs on remote servers that are hosted on the internet instead of the computer's hard drive or local server. Cloud computing is also referred to as Internet-based computing, it is a technology where the resource is provided as a service through the Internet to the user. The data that is stored can be files, images, documents, or any other storable document.

Advantages of Cloud Computing

- Cost Saving
- Data Redundancy and Replication
- Ransomware/Malware Protection
- Flexibility
- Reliability
- High Accessibility
- Scalable

Disadvantages of Cloud Computing

- Internet Dependency
- Issues in Security and Privacy
- Data Breaches
- Limitations on Control

Conclusion

In Conclusion cloud computing has become an important component of modern IT infrastructure, offering excellent flexibility, scalability, and efficiency. It has not only overcome the constraints of prior computing models, but it has also created the path for new applications and services that will keep advancing technological progress and economic growth.

Frequently Asked Questions on Cloud Computing – FAQs

When did the cloud start to evolve?

This notion was first proposed in the mid-1990s. It gained popularity following the advent of Google Cloud Platform, Microsoft Azure, and Amazon Web Services.

What are the three major types of cloud computing services?

- *Infrastructure-as-a-Service (IaaS)*
- *Platforms-as-a-Service (PaaS)*
- *Software-as-a-Service (SaaS)*