UNIT 1

Basics of Cloud computing

Introduction to cloud computing: Introduction, Characteristics of cloud computing, Cloud Models, Cloud Services Examples, Cloud Based services and applications

Cloud concepts and Technologies: Virtualization, Load balancing, Scalability and Elasticity, Deployment, Replication, Monitoring, Software defined, Network function virtualization, Map Reduce, Identity and Access Management, services level Agreements, Billing.

Cloud Services and Platforms: Compute Services, Storage Services, Database Services, Application services, Content delivery services, Analytics Services, Deployment and Management Services, Identity and Access Management services, Open Source Private Cloud software.

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Cloud Computing provides us means of accessing the applications as utilities over the Internet. It allows us to create, configure, and customize the applications online.

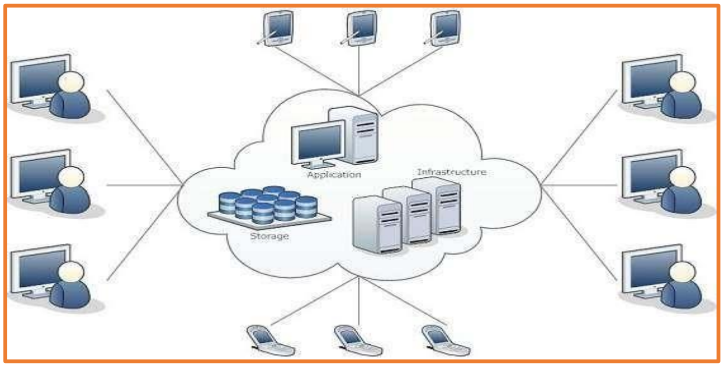
What is Cloud?

The term Cloud refers to a Network or Internet. In other words, we can say that Cloud is something, which is present at remote location. Cloud can provide services over public and private networks, i.e., WAN, LAN or VPN.

Applications such as e-mail, web conferencing, customer relationship management (CRM) execute on cloud.

What is Cloud Computing?

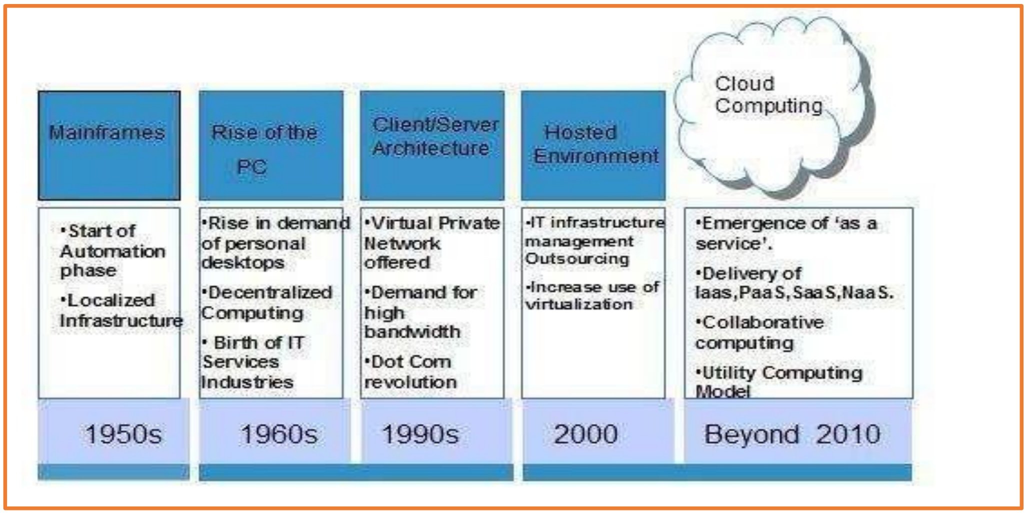
Cloud Computing refers to manipulating, configuring, and accessing the hardware and software resources remotely. It offers online data storage, infrastructure, and application.



Cloud computing offers platform independency, as the software is not required to be installed locally on the PC. Hence, the Cloud Computing is making our business applications mobile and collaborative.

History of Cloud Computing

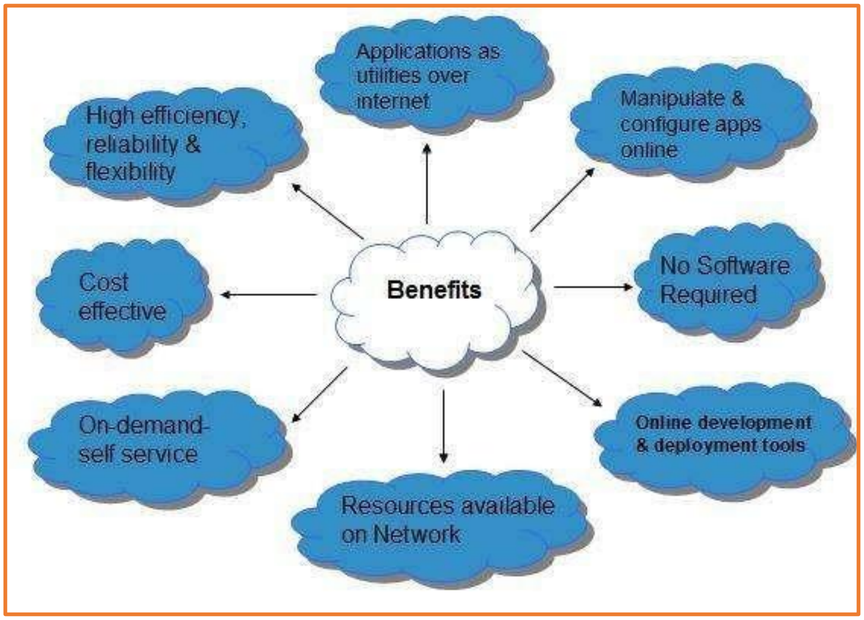
The concept of Cloud Computing came into existence in the year 1950 with implementation of mainframe computers, accessible via thin/static clients. Since then, cloud computing has been evolved from static clients to dynamic ones and from software to services. The following diagram explains the evolution of cloud computing:


Mainframes
Rise of the PC
Client/Server Architecture
Hosted Environment
Cloud Computing
•Start of Automation phase
•Localized Infrastructure
•Rise in demand of personal desktops
•Decentralized Computing
• Birth of IT Services Industries
•Virtual Private Network offered
•Demand for high bandwidth
•Dot Com revolution
•IT infrastructure management Outsourcing
•Increase use of virtualization
•Emergence of 'as a service'.
•Delivery of Iaas,PaaS,SaaS,NaaS.
•Collaborative computing
•Utility Computing Model
1950s
1960s
1990s
2000
Beyond 2010

Benefits

Cloud Computing has numerous advantages. Some of them are listed below -

- One can access applications as utilities, over the Internet.
- One can manipulate and configure the applications online at any time.
- It does not require to install a software to access or manipulate cloud application.
- Cloud Computing offers online development and deployment tools, programming runtime environment through PaaS model.
- Cloud resources are available over the network in a manner that provide platform independent access to any type of clients.
- Cloud Computing offers on-demand self-service. The resources can be used without interaction with cloud service provider.
- Cloud Computing is highly cost effective because it operates at high efficiency with optimum utilization. It just requires an Internet connection
- Cloud Computing offers load balancing that makes it more reliable.


Applications as utilities over internet
High efficiency, reliability & flexibility
Manipulate & configure apps online
Cost effective
Benefits
No Software Required
On-demand self service
Online development & deployment tools
Resources available on Network

Characteristics of Cloud Computing

There are four key characteristics of cloud computing. They are shown in the following

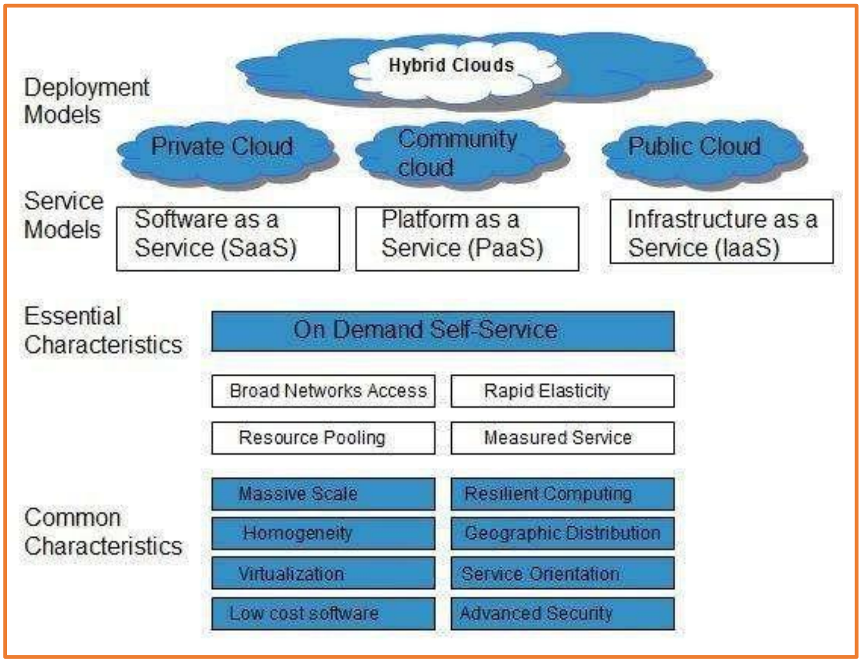


diagram:

On Demand Self Service

Cloud Computing allows the users to use web services and resources on demand. One can logon to a website at any time and use them.

Broad Network Access

Since cloud computing is completely web based, it can be accessed from anywhere and at any time.

Resource Pooling

Cloud computing allows multiple tenants to share a pool of resources. One can share single physical instance of hardware, database and basic infrastructure.

Rapid Elasticity

It is very easy to scale the resources vertically or horizontally at any time. Scaling of resources means the ability of resources to deal with increasing or decreasing demand.

The resources being used by customers at any given point of time are automatically monitored.

Measured Service

In this service cloud provider controls and monitors all the aspects of cloud service. Resource optimization, billing, and capacity planning etc. depend on it.

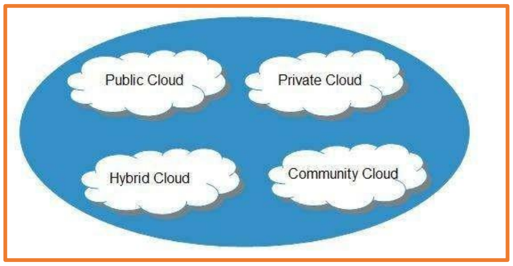
Cloud Models:

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

Deployment Models

Deployment models define the type of access to the cloud, i.e., how the cloud is located? Cloud can have any of the four types of access: Public, Private, Hybrid, and Community.



Public Cloud

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.

Private Cloud

The private cloud allows systems and services to be accessible within an organization. It is more secured because of its private nature.

Community Cloud

The community cloud allows systems and services to be accessible by a group of organizations.

Hybrid Cloud

The hybrid cloud is a mixture of public and private cloud, in which the critical activities are performed using private cloud while the non-critical activities are performed using public cloud.

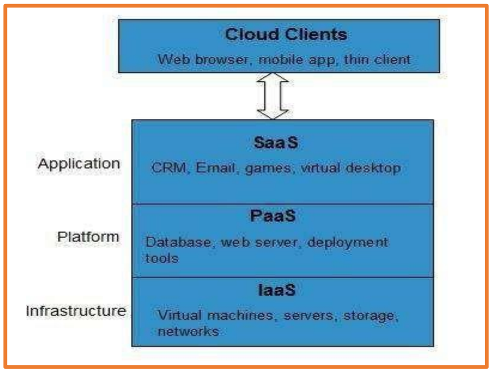
Service Models

Cloud computing is based on service models. These are categorized into three basic service models which are -

- Infrastructure-as–a-Service (IaaS)
- Platform-as-a-Service (PaaS)
- Software-as-a-Service (SaaS)

Anything-as-a-Service (XaaS) is yet another service model, which includes Network- as-a-Service, Business-as-a-Service, Identity-as-a-Service, Database-as-a-Service or Strategy- as-a-Service.

The Infrastructure-as-a-Service (IaaS) is the most basic level of service. Each of the service models inherit the security and management mechanism from the underlying model, as shown in the following diagram:


Cloud Clients
Web browser, mobile app, thin client
Application
SaaS
CRM, Email, games, virtual desktop
Platform
PaaS
Database, web server, deployment tools
Infrastructure
IaaS
Virtual machines, servers, storage, networks

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 and deployment tools, etc.

Software-as-a-Service (SaaS)

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

Risks related to Cloud Computing

Although cloud Computing is a promising innovation with various benefits in the world of computing, it comes with risks. Some of them are discussed below:

Security and Privacy

It is the biggest concern about cloud computing. Since data management and infrastructure management in cloud is provided by third-party, it is always a risk to handover the sensitive information to cloud service providers.

Although the cloud computing vendors ensure highly secured password protected accounts, any sign of security breach may result in loss of customers and businesses.

Lock In

It is very difficult for the customers to switch from one Cloud Service Provider (CSP) to another. It results in dependency on a particular CSP for service.

Isolation Failure

This risk involves the failure of isolation mechanism that separates storage, memory, and routing between the different tenants.

Management Interface Compromise

In case of public cloud provider, the customer management interfaces are accessible through the Internet.

Insecure or Incomplete Data Deletion

It is possible that the data requested for deletion may not get deleted. It happens because either of the following reasons

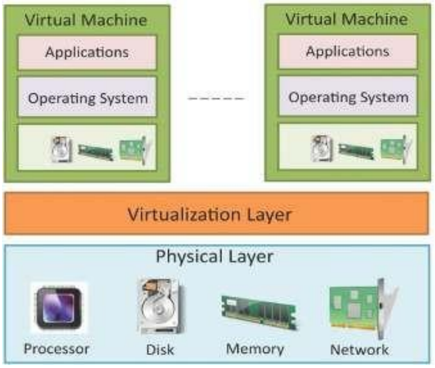
- Extra copies of data are stored but are not available at the time of deletion
- Disk that stores data of multiple tenants is destroyed.

Virtualization In Cloud Computing

We need to understand the meaning of the word virtual. The word virtual means that it is a representation of something physically present elsewhere.

Similarly, Virtualization in Cloud Computing is a technology that allows us to create virtual resources such as servers, networks, and storage in the cloud. All these resources are allocated from a physical machine that runs somewhere in the world, and we'll get the software to provision and manage these virtual resources. These physical machines are operated by cloud providers, who take care of maintenance, and hardware supplies.

- Virtualization refers to the partitioning the resources of a physical system (such as computing, storage, network and memory) into multiple virtual resources.
- Key enabling technology of cloud computing that allow pooling of resources.
- In cloud computing, resources are pooled to serve multiple users using multi-tenancy.



Some of virtualization in cloud computing examples are as follows

- EC2 service from Amazon Web Service
- Compute engine from Google Cloud
- Azure Virtual Machines from Microsoft Azure

Concept Behind Virtualization

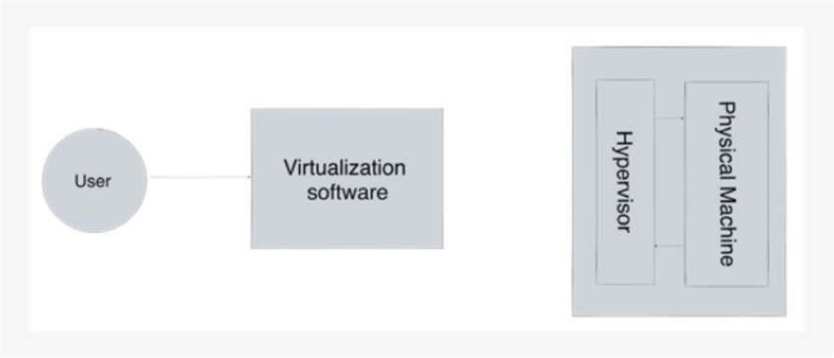
The main concept behind virtualization is Hypervisor. Hypervisor is a software that partitions the hardware resources on the physical machine and runs Virtual Machine.

It is typically installed on the server's hardware and divides the resources for Virtual machines (VMs).

The server running hypervisor is called the Host, and the VMs using its resources are called Guest Operating Systems.

The VMs function like digital files inside the physical device and they can be moved from one system to another, thereby increasing the portability. There are many open-source and paid Hypervisors available. Cloud providers use them based on their requirements and business needs.

Virtualization Work in Cloud Computing



Important Terminologies of Virtualization

1. Virtual Machine (VM)

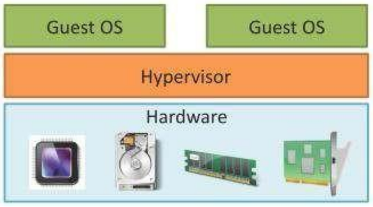
The virtual machine that simulates an actual computer, these VMs come with an operating system (OS) already installed and executes the application that is installed inside them. These virtual machines are controlled and managed by the Hypervisor.

2. Hypervisor

A hypervisor is software that partitions the hardware resources on the physical machine and runs Virtual Machine on them. This is responsible to create and provision virtual resources when there is a request.

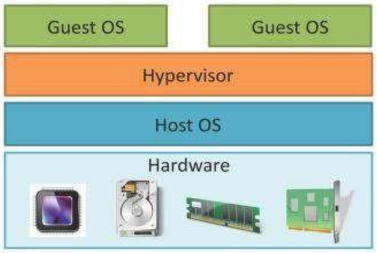
Type-1 Hypervisor:

Type-I or the native hypervisors run directly on the host hardware and control the hardware and monitor the guest operating systems.



Type-2 Hypervisor:

Type 2 hypervisors or hosted hypervisors run on top of a conventional (main/host) operating system and monitor the guest operating systems.



3. Virtualization software

A tool that works on deploying virtualization on the device, this is the software that the user interacts with for specifying virtual resources requirements. This software communicates with the hypervisor for the resource requirements.

4. Virtual Networking

The Virtual Networking, the network that is configured inside the servers is separated logically these networks can be scaled across multiple servers, and these networks can be controlled by the software.

Types of Virtualization:

Full Virtualization

Full Virtualization is virtualization in which the guest operating system is unaware that it is in a virtualized environment, and therefore hardware is virtualized by the host operating system so that the guest can issue commands to what it thinks is actual hardware, but really are just simulated hardware devices created by the host.

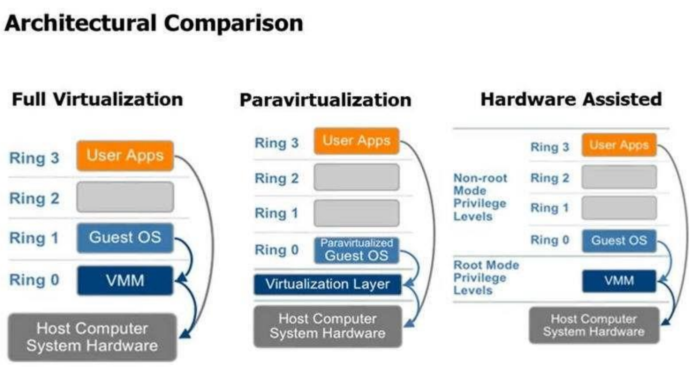
Para-Virtualization

Para-Virtualization is virtualization in which the guest operating system (the one being virtualized) is aware that it is a guest and accordingly has drivers that, instead of issuing hardware commands, simply issues commands directly to the host operating system. This will include things such as memory management as well.

Hardware Virtualization

Hardware assisted virtualization is enabled by hardware features such as Intel's Virtualization Technology (VT-x) and AMD's AMD-V.

In hardware assisted virtualization, privileged and sensitive calls are set to automatically trap to the hypervisor. Thus, there is no need for either binary translation or para-virtualization.



Load balancing in Cloud Computing

Cloud load balancing is defined as the method of splitting workloads and computing properties in a cloud computing. It enables enterprise to manage workload demands or application demands by distributing resources among numerous computers, networks or servers. Cloud load balancing includes holding the circulation of workload traffic and demands that exist over the Internet.

As the traffic on the internet growing rapidly, which is about 100% annually of the present traffic. Hence, the workload on the server growing so fast which leads to the overloading of servers mainly for popular web server. There are two elementary solutions to overcome the problem of overloading on the servers-

- First is a single-server solution in which the server is upgraded to a higher performance server. However, the new server may also be overloaded soon, demanding another upgrade. Moreover, the upgrading process is arduous and expensive.
- Second is a multiple-server solution in which a scalable service system on a cluster of servers is built. That’s why it is more cost effective as well as more scalable to build a server cluster system for network services.

Load balancing is beneficial with almost any type of service, like HTTP, SMTP, DNS, FTP, and POP/IMAP. It also rises reliability through redundancy. The balancing service is provided by a dedicated hardware device or program. Cloud-based servers farms can attain more precise scalability and availability using server load balancing.

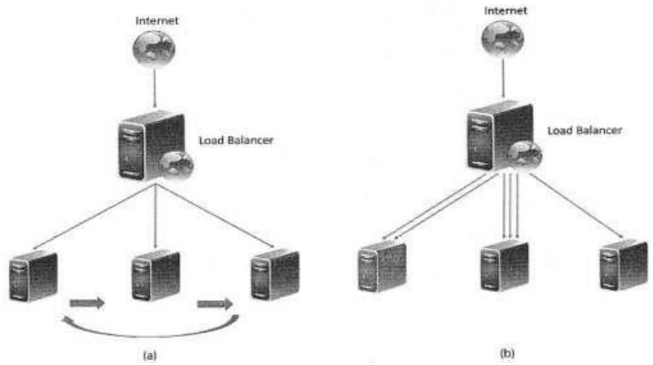
Load balancing solutions can be categorized into two types –

1. Software-based load balancers: Software-based load balancers run on standard hardware (desktop, PCs) and standard operating systems.
2. Hardware-based load balancer: Hardware-based load balancers are dedicated

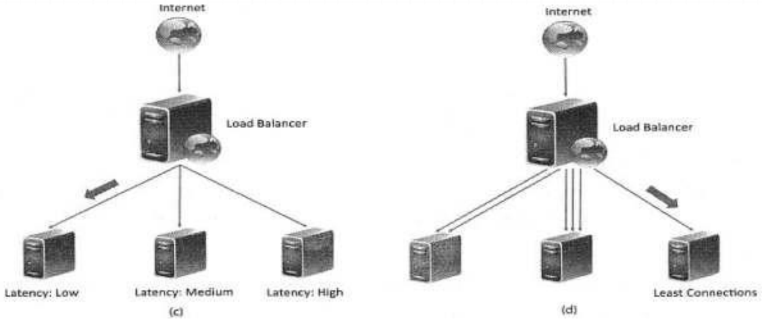
boxes which include Application Specific Integrated Circuits (ASICs) adapted for a particular use. ASICs allows high speed promoting of network traffic and are frequently used for transport-level load balancing because hardware-based load balancing is faster in comparison to software solution.

Load Balancing Algorithms

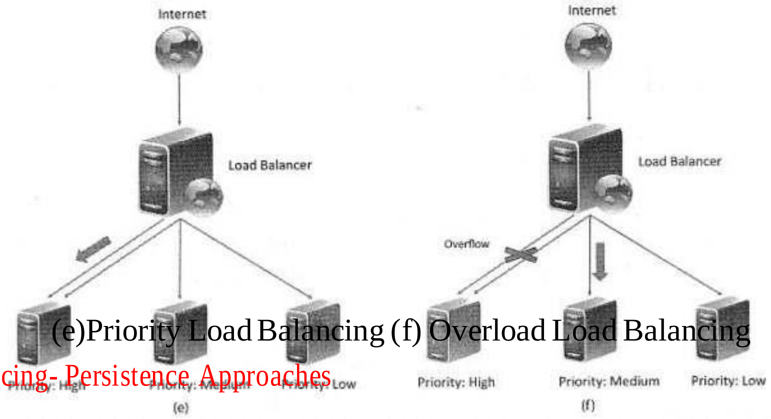
- Round Robin load balancing
- Weighted Round Robin load balancing
- Low Latency load balancing
- Least Connections load balancing
- Priority load balancing
- Overflow load balancing



(a) Round Robin Load Balancing (b) Weighted Round Robin Load Balancing



(c)Low Latency Load Balancing (d) Least connections Load Balancing



(e)Priority Load Balancing (f) Overload Load Balancing

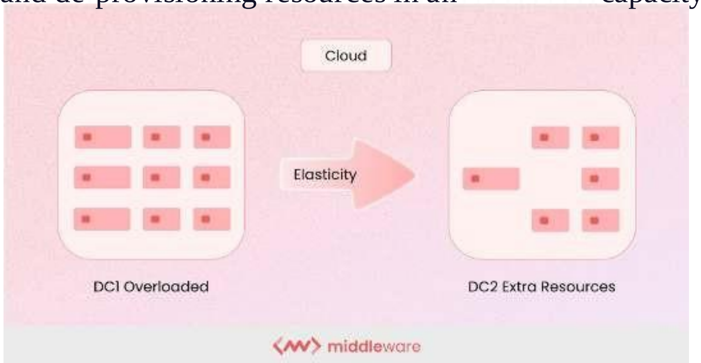
Load Balancing- Persistence Approaches

- Since load balancing can route successive requests from a user session to different servers, maintaining the state or the information of the session is important.
- Persistence Approaches
  - Sticky sessions
  - Session Database
  - Browser cookies
  - URL re-writing

Cloud Elasticity

Cloud elasticity is a system's ability to increase (or decrease) its varying capacity-related needs such as storage, networking, and computing based on specific criteria (think: total load on the system).

Simply put, elasticity adapts to both the increase and decrease in workload by provisioning and de-provisioning resources in an *autonomous* capacity.



Here are some of its distinctive characteristics:

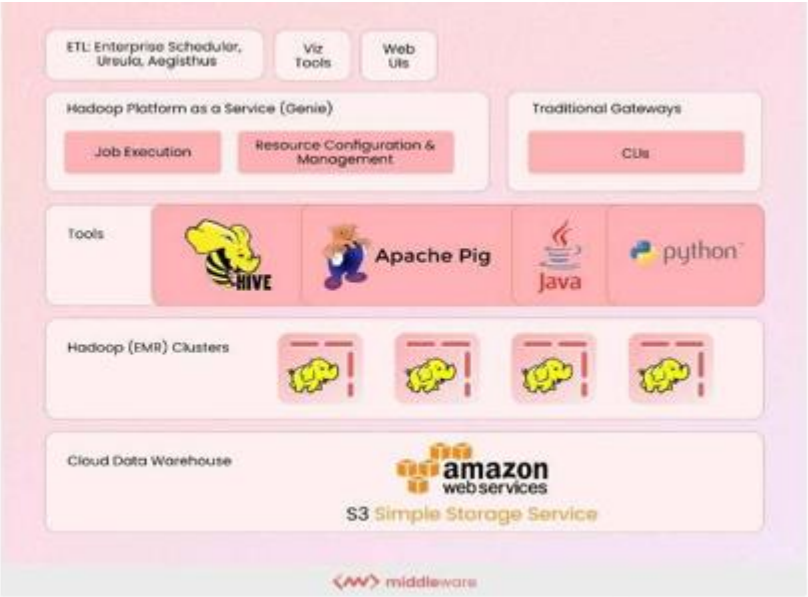
- Matches the allocated resources with the actual resources in real-time
- Widely used in e-commerce and retail, software as a service (SaaS), DevOps, mobile, and other cloud environments with ever-changing infrastructure demands

Example of cloud elasticity : Cloud elasticity refers to scaling up (or scaling down) the computing capacity as needed. It basically helps you understand how well your architecture can adapt to the workload in real time.

For example, 100 users log in to your website every hour. A single server can easily handle this volume of traffic. However, what happens if 5000 users log in at the same time? If your existing architecture can quickly and automatically provision new web servers to handle this load, your design is elastic.

As you can imagine, cloud elasticity comes in handy when your business experiences sudden spikes in user activity and, with it, a drastic increase in workload demand — as happens in businesses such as streaming services or e-commerce marketplaces.

Take the video streaming service Netflix, for example. Here's how Netflix's architecture leverages the power of elasticity to scale up and down:



Cloud Scalability

Cloud scalability only adapts to the workload increase through the incremental provision of resources without impacting the system's overall performance. This is built in as part of the infrastructure design instead of makeshift resource allocation (as with cloud elasticity).

Below are some of its main features:

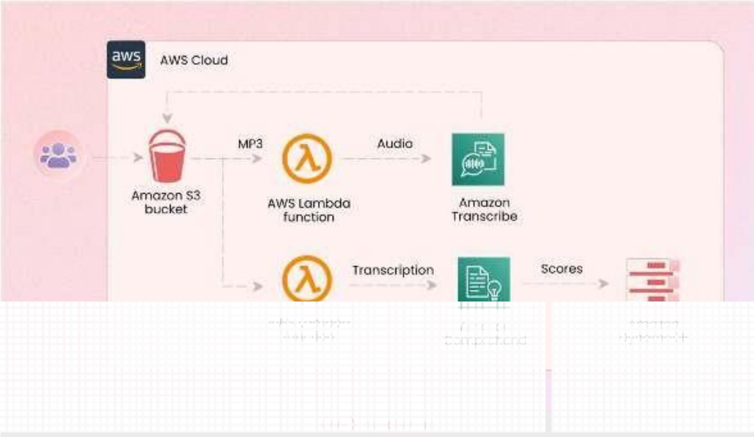
- Typically handled by adding resources to existing instances, also known as scaling up or vertical scaling, or by adding more copies of existing instances, also known as scaling out or horizontal scaling
- Allows companies to implement big data models for machine learning (ML) and data analysis

- Handles rapid and unpredictable changes in a scalable capacity
- Generally more granular and targeted than elasticity in terms of sizing
- Ideal for businesses with a predictable and preplanned workload where capacity planning and performance are relatively stable

Example of cloud scalability : Cloud scalability has many examples and use cases. It allows you to scale up or scale out to meet the increasing workloads. You can scale up a platform or architecture to increase the performance of an individual server.

Usually, this means that hardware costs increase linearly with demand. On the flip side, you can also add multiple servers to a single server and scale out to enhance server performance and meet the growing demand.

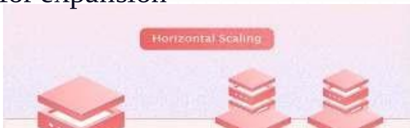
Another good example of cloud scalability is a call center. A call center requires a scalable application infrastructure as new employees join the organization and customer requests increase incrementally. As a result, organizations need to add new server features to ensure consistent growth and quality performance.



Types of scalability: Typically, there are three types of scalability:

1. Vertical scaling (scaling up) : This type of scalability is best-suited when you experience increased workloads and add resources to the existing infrastructure to improve server performance. If you’re looking for a short-term solution to your immediate needs, vertical scaling may be your calling.

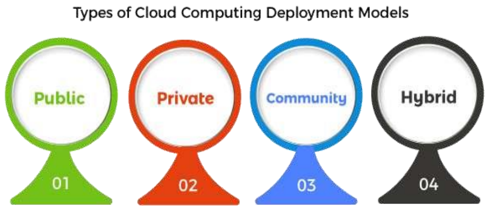
2. Horizontal scaling (scaling out): It enables companies to add new elements to their existing infrastructure to cope with ever-increasing workload demands. However, this horizontal scaling is designed for the long term and helps meet current and future resource needs, with plenty of room for expansion



3. Diagonal scaling : Diagonal scaling involves horizontal and vertical scaling. It’s more flexible and cost-effective as it helps add or remove resources as per existing workload requirements. Adding and upgrading resources according to the varying system load and demand provides better throughput and optimizes resources for even better performance.

Cloud Deployment Model: It works as your virtual computing environment with a choice of deployment model depending on how much data you want to store and who has access to the Infrastructure.

- Cloud application deployment design is an iterative process that involves:
  - Deployment Design
    - The variables in this step include the number of servers in each tier, computing, memory and storage capacities of severs, server interconnection, load balancing and replication strategies.
  - Performance Evaluation
    - To verify whether the application meets the performance requirements with the deployment.
    - Involves monitoring the workload on the application and measuring various workload parameters such as response time and throughput.
    - Utilization of servers (CPU, memory, disk, I/O, etc.) in each tier is also monitored.
  - Deployment Refinement
    - Various alternatives can exist in this step such as vertical scaling (or scaling up), horizontal scaling (or scaling out), alternative server interconnections, alternative load balancing and replication strategies, for instance.

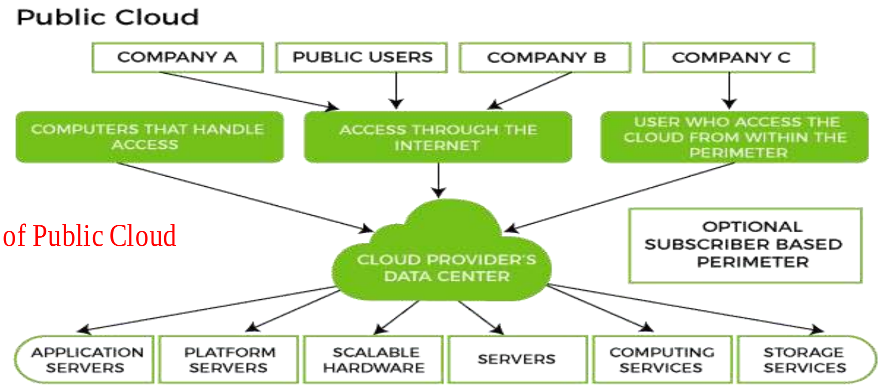


Different Types Of Cloud Computing Deployment Models

Most cloud hubs have tens of thousands of servers and storage devices to enable fast loading. It is often possible to choose a geographic area to put the data "closer" to users. Thus, deployment models for cloud computing are categorized based on their location. To know which model would best fit the requirements of your organization, let us first learn about the various types.

Public Cloud: The name says it all. It is accessible to the public. Public deployment models in the cloud are perfect for organizations with growing and fluctuating demands. It also makes a great choice for companies with low-security concerns.

Thus, you pay a cloud service provider for networking services, compute virtualization & storage available on the public internet. It is also a great delivery model for the teams with development and testing. Its configuration and deployment are quick and easy, making it an ideal choice for test environments.

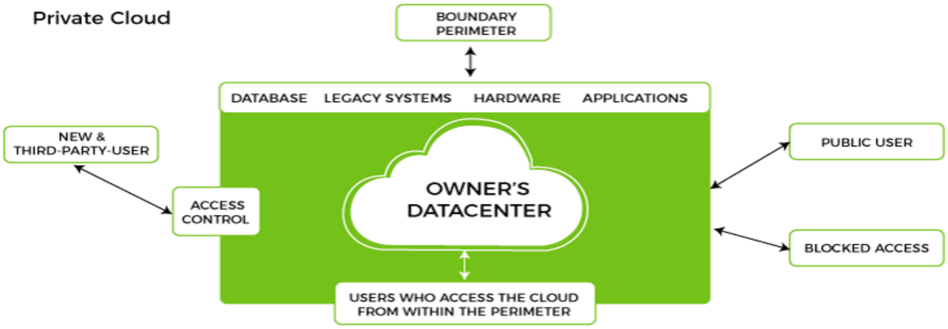

Public Cloud
COMPANY A
PUBLIC USERS
COMPANY B
COMPANY C
COMPUTERS THAT HANDLE ACCESS
ACCESS THROUGH THE INTERNET
USER WHO ACCESS THE CLOUD FROM WITHIN THE PERIMETER
CLOUD PROVIDER'S DATA CENTER
OPTIONAL SUBSCRIBER BASED PERIMETER
APPLICATION SERVERS
PLATFORM SERVERS
SCALABLE HARDWARE
SERVERS
COMPUTING SERVICES
STORAGE SERVICES

Benefits of Public Cloud

- Minimal Investment - As a pay-per-use service, there is no large upfront cost and is ideal for businesses who need quick access to resources
- No Hardware Setup - The cloud service providers fully fund the entire Infrastructure
- No Infrastructure Management - This does not require an in-house team to utilize the public cloud.

Private Cloud: Companies that look for cost efficiency and greater control over data & resources will find the private cloud a more suitable choice.

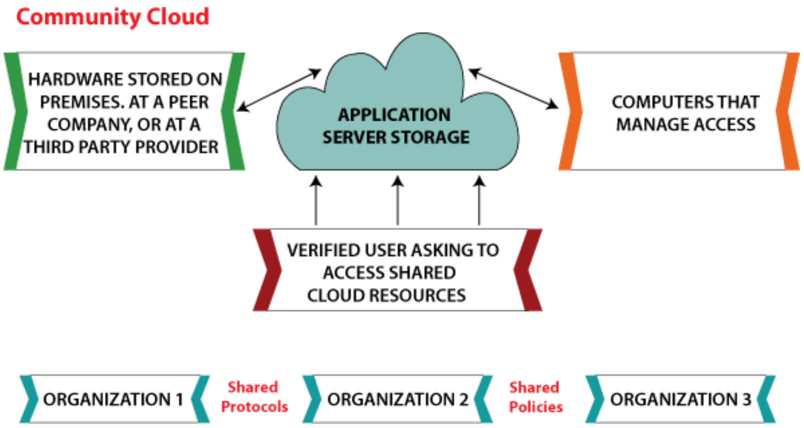
It means that it will be integrated with your data center and managed by your IT team. Alternatively, you can also choose to host it externally. The private cloud offers bigger opportunities that help meet specific organizations' requirements when it comes to customization. It's also a wise choice for mission-critical processes that may have frequently changing requirements.



Benefits of Private Cloud

- Data Privacy - It is ideal for storing corporate data where only authorized personnel gets access
- Security - Segmentation of resources within the same Infrastructure can help with better access and higher levels of security.
- Supports Legacy Systems - This model supports legacy systems that cannot access the public cloud.

Community Cloud : The community cloud operates in a way that is similar to the public cloud. There's just one difference - it allows access to only a specific set of users who share common objectives and use cases. This type of deployment model of cloud computing is managed and hosted internally or by a third-party vendor. However, you can also choose a combination of all three.

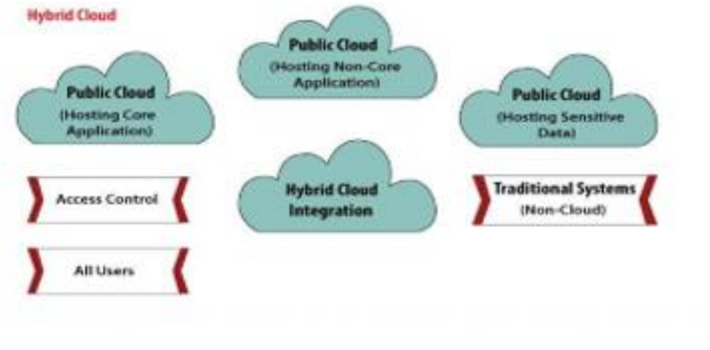

Community Cloud
HARDWARE STORED ON PREMISES. AT A PEER COMPANY, OR AT A THIRD PARTY PROVIDER
APPLICATION SERVER STORAGE
COMPUTERS THAT MANAGE ACCESS
VERIFIED USER ASKING TO ACCESS SHARED CLOUD RESOURCES
ORGANIZATION 1
Shared Protocols
ORGANIZATION 2
Shared Policies
ORGANIZATION 3

Benefits of Community Cloud

- Smaller Investment - A community cloud is much cheaper than the private & public cloud and provides great performance
- Setup Benefits - The protocols and configuration of a community cloud must align with industry standards, allowing customers to work much more efficiently.
-

Hybrid Cloud : As the name suggests, a hybrid cloud is a combination of two or more cloud architectures. While each model in the hybrid cloud functions differently, it is all part of the same architecture. Further, as part of this deployment of the cloud computing model, the internal or external providers can offer resources.

Let's understand the hybrid model better. A company with critical data will prefer storing on a private cloud, while less sensitive data can be stored on a public cloud. The hybrid cloud is also frequently used for 'cloud bursting'. It means, supposes an organization runs an application on-premises, but due to heavy load, it can burst into the public cloud.


Hybrid Cloud
Public Cloud
(Hosting Non-Core Application)
Public Cloud
(Hosting Core Application)
Public Cloud
(Hosting Sensitive Data)
Access Control
Hybrid Cloud Integration
Traditional Systems
(Non-Cloud)
All Users

Replication:

- Replication is used to create and maintain multiple copies of the data in the cloud.
- Cloud enables rapid implementation of replication solutions for disaster recovery for organizations.
- With cloud-based data replication organizations can plan for disaster recovery without making any capital expenditures on purchasing, configuring and managing secondary site locations.
- Types:
  - Array-based Replication
  - Network-based Replication
  - Host-based Replication

Cloud Monitoring:

Cloud monitoring is the process of reviewing and managing the operational workflow and processes within a cloud infrastructure or asset. It's generally implemented through automated monitoring software that gives central access and control over the cloud infrastructure.

Admins can review the operational status and health of cloud servers and components.

Concerns arise based on the type of cloud structure you have, and your strategy for using it. If you're using a public cloud service, you tend to have limited control and visibility for managing and monitoring the infrastructure. A private cloud, which most large organizations use, provides the internal IT department more control and flexibility, with added consumption benefits.

Regardless of the type of cloud structure your company uses, monitoring is critical to performance and security.

How Cloud Monitoring Works

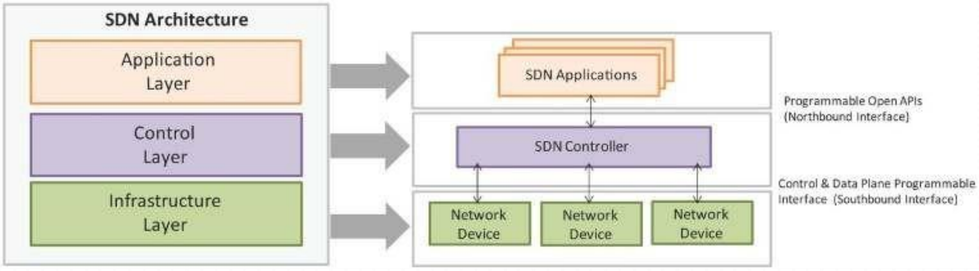
The cloud has many moving parts, and it's important to ensure everything works together seamlessly to optimize performance. Cloud monitoring primarily includes functions such as:

- Website monitoring: Tracking the processes, traffic, availability and resource utilization of cloud-hosted websites
- Virtual machine monitoring: Monitoring the virtualization infrastructure and individual virtual machines
- Database monitoring: Monitoring processes, queries, availability, and consumption of cloud database resources

- Virtual network monitoring: Monitoring virtual network resources, devices, connections, and performance
- Cloud storage monitoring: Monitoring storage resources and their processes provisioned to virtual machines, services, databases, and applications

Software Defined Networking

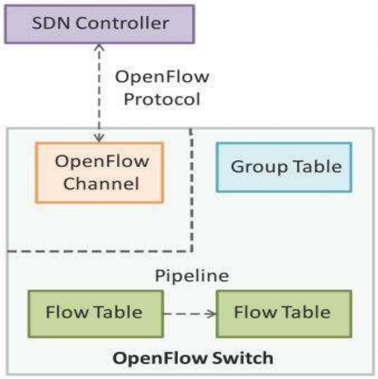
- Software-Defined Networking (SDN) is a networking architecture that separates the control plane from the data plane and centralizes the network controller.
- Conventional network architecture
  - The control plane and data plane are coupled. Control plane is the part of the network that carries the signalling and routing message traffic while the data plane is the part of the network that carries the payload data traffic.
- SDN Architecture
  - The control and data planes are decoupled and the network controller is centralized.
- Centralized Network Controller
  - With decoupled the control and data planes and centralized network controller, the network administrators can rapidly configure the network.
- Programmable Open APIs
  - SDN architecture supports programmable open APIs for interface between the SDN application and control layers (Northbound interface). These open APIs that allow implementing various network services such as routing, quality of service (QoS), access control, etc.
- Standard Communication Interface (OpenFlow)
  - SDN architecture uses a standard communication interface between the control and infrastructure layers(Southbound interface). OpenFlow, which is defined by the Open Networking Foundation (ONF) is the broadly accepted SDN protocol for the Southbound interface.



OpenFlow

- OpenFlow is the broadly accepted SDN protocol for the Southbound interface.
- With OpenFlow, the forwarding plane of the network devices can be directly accessed and manipulated.
- OpenFlow uses the concept of flows to identify network traffic based on pre-defined match rules.

- Flows can be programmed statically or dynamically by the SDN control software.
- OpenFlow protocol is implemented on both sides of the interface between the controller and the network devices.



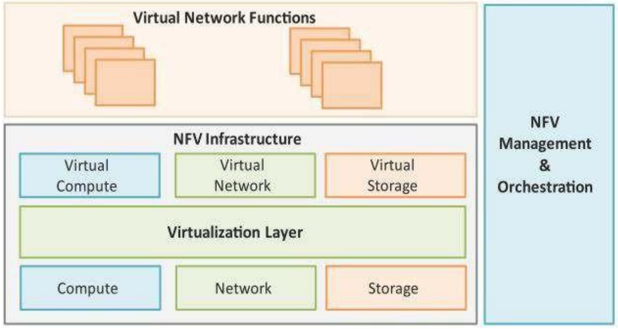
OpenFlow switch comprising of one or more flow tables and a group table, which perform packet lookups and forwarding, and OpenFlow channel to an external controller.

Network Function Virtualization:

- Network Function Virtualization (NFV) is a technology that leverages virtualization to consolidate the heterogeneous network devices onto industry standard high volume servers, switches and storage.
- Relationship to SDN
  - NFV is complementary to SDN as NFV can provide the infrastructure on which SDN can run.
  - NFV and SDN are mutually beneficial to each other but not dependent.
  - Network functions can be virtualized without SDN, similarly, SDN can run without NFV.
  - NFV comprises of network functions implemented in software that run on virtualized resources in the cloud.
- NFV enables a separation the network functions which are implemented in software from the underlying hardware.

NFV Architecture

- Key elements of the NFV architecture are
  - Virtualized Network Function (VNF): VNF is a software implementation of a network function which is capable of running over the NFV Infrastructure (NFVI).
  - NFV Infrastructure(NFVI): NFVI includes compute, network and storage resources that are virtualized.
  - NFV Management and Orchestration: NFV Management and Orchestration focuses on all virtualization-specific management tasks and covers the orchestration and lifecycle management of physical and/or software resources that support the infrastructure virtualization, and the lifecycle management of VNFs.



MapReduce: MapReduce is a processing technique and a program model for distributed computing based on java.

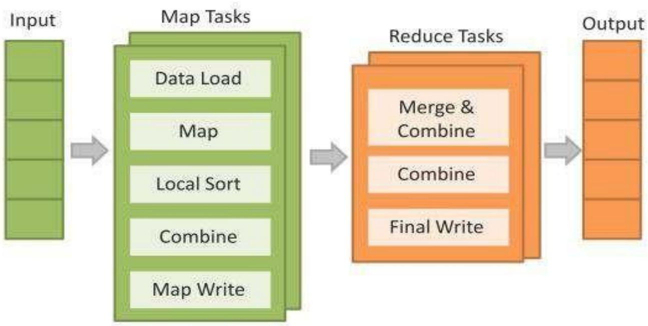
The MapReduce algorithm contains two important tasks, namely Map and Reduce.

- Map takes a set of data and converts it into another set of data, where individual elements are broken down into tuples (key/value pairs).
- Secondly, reduce task, which takes the output from a map as an input and combines those data tuples into a smaller set of tuples. As the sequence of the name MapReduce implies, the reduce task is always performed after the map job.
- The major advantage of MapReduce is that it is easy to scale data processing over multiple computing nodes.
- Under the MapReduce model, the data processing primitives are called mappers and reducers. Decomposing a data processing application into *mappers* and *reducers* is sometimes nontrivial.
- But, once we write an application in the MapReduce form, scaling the application to run over hundreds, thousands, or even tens of thousands of machines in a cluster is merely a configuration change. This simple scalability is what has attracted many programmers to use the MapReduce model.

The Algorithm

- Generally MapReduce paradigm is based on sending the computer to where the data resides!
- MapReduce program executes in three stages, namely map stage, shuffle stage, and reduce stage.
    - Map stage – The map or mapper's job is to process the input data. Generally the input data is in the form of file or directory and is stored in the Hadoop file system (HDFS). The input file is passed to the mapper function line by line. The mapper processes the data and creates several small chunks of data.
    - Reduce stage – This stage is the combination of the Shuffle stage and the Reduce stage. The Reducer's job is to process the data that comes from the mapper. After processing, it produces a new set of output, which will be stored in the HDFS.
- During a MapReduce job, Hadoop sends the Map and Reduce tasks to the appropriate servers in the cluster.
- The framework manages all the details of data-passing such as issuing tasks, verifying task completion, and copying data around the cluster between the nodes.

- Most of the computing takes place on nodes with data on local disks that reduces the network traffic.
- After completion of the given tasks, the cluster collects and reduces the data to form an appropriate result, and sends it back to the Hadoop server.



Terminology

- ▸ PayLoad − Applications implement the Map and the Reduce functions, and form the core of the job.
- ▸ Mapper − Mapper maps the input key/value pairs to a set of intermediate key/value pair.
- ▸ NamedNode − Node that manages the Hadoop Distributed File System (HDFS).
- ▸ DataNode − Node where data is presented in advance before any processing takes place.
- ▸ MasterNode − Node where JobTracker runs and which accepts job requests from clients.
- ▸ SlaveNode − Node where Map and Reduce program runs.
- ▸ JobTracker − Schedules jobs and tracks the assign jobs to Task tracker.
- ▸ Task Tracker − Tracks the task and reports status to JobTracker.
- ▸ Job − A program is an execution of a Mapper and Reducer across a dataset.
- ▸ Task − An execution of a Mapper or a Reducer on a slice of data.
- ▸ Task Attempt − A particular instance of an attempt to execute a task on a SlaveNode.

Service level agreements in Cloud computing

A Service Level Agreement (SLA) is the bond for performance negotiated between the cloud services provider and the client. Earlier, in cloud computing all Service Level Agreements were negotiated between a client and the service consumer.

Service level agreements are also defined at different levels which are mentioned below:

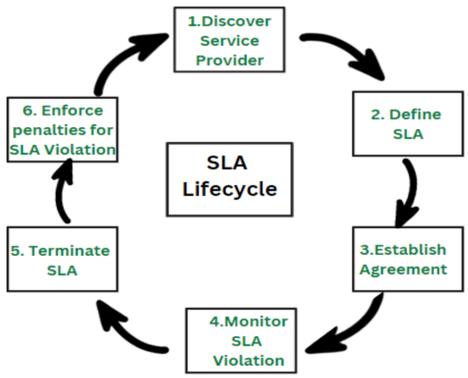
- Customer-based SLA
- Service-based SLA
- Multilevel SLA

Few Service Level Agreements are enforceable as contracts, but mostly are agreements or contracts which are more along the lines of an Operating Level Agreement (OLA) and may not have the restriction of law. It is fine to have an attorney review the documents before making a major agreement to the cloud service provider. Service Level Agreements usually specify some parameters which are mentioned below:

- Availability of the Service (uptime)
- Latency or the response time
- Service components reliability
- Each party accountability
- Warranties

Each individual component has its own Service Level Agreements. Below are two major Service Level Agreements (SLA) described:

1. Windows Azure SLA ——— Window Azure has different SLA's for compute and storage. For compute, there is a guarantee that when a client deploys two or more role instances in separate fault and upgrade domains, client's internet facing roles will have external connectivity minimum 99.95% of the time. Moreover, all of the role instances of the client are monitored and there is guarantee of detection 99.9% of the time when a role instance's process is not runs and initiates properly.
2. SQL Azure SLA – SQL Azure clients will have connectivity between the database and internet gateway of SQL Azure. SQL Azure will handle a "Monthly Availability" of 99.9% within a month. Monthly Availability Proportion for a particular tenant database is the ratio of the time the database was available to customers to the total time in a month. Time is measured in some intervals of minutes in a 30-day monthly cycle. Availability is always remunerated for a complete month. A portion of time is marked as unavailable if the customer's attempts to connect to a database are denied by the SQL Azure gateway.



SLA Lifecycle

Steps in SLA Lifecycle

1. Discover service provider: This step involves identifying a service provider that can meet the needs of the organization and has the capability to provide the required service. This can be done through research, requesting proposals, or reaching out to vendors.
2. Define SLA: In this step, the service level requirements are defined and agreed upon between the service provider and the organization. This includes defining the

service level objectives, metrics, and targets that will be used to measure the performance of the service provider.

3. Establish Agreement: After the service level requirements have been defined, an agreement is established between the organization and the service provider outlining the terms and conditions of the service. This agreement should include the SLA, any penalties for non-compliance, and the process for monitoring and reporting on the service level objectives.
4. Monitor SLA violation: This step involves regularly monitoring the service level objectives to ensure that the service provider is meeting their commitments. If any violations are identified, they should be reported and addressed in a timely manner.
5. Terminate SLA: If the service provider is unable to meet the service level objectives, or if the organization is not satisfied with the service provided, the SLA can be terminated. This can be done through mutual agreement or through the enforcement of penalties for non-compliance.
6. Enforce penalties for SLA Violation: If the service provider is found to be in violation of the SLA, penalties can be imposed as outlined in the agreement. These penalties can include financial penalties, reduced service level objectives, or termination of the agreement.

Advantages of SLA

1. Improved communication: A better framework for communication between the service provider and the client is established through SLAs, which explicitly outline the degree of service that a customer may anticipate. This can make sure that everyone is talking about the same things when it comes to service expectations.
2. Increased accountability: SLAs give customers a way to hold service providers accountable if their services fall short of the agreed-upon standard. They also hold service providers responsible for delivering a specific level of service.
3. Better alignment with business goals: SLAs make sure that the service being given is in line with the goals of the client by laying down the performance goals and service level requirements that the service provider must satisfy.
4. Reduced downtime: SLAs can help to limit the effects of service disruptions by creating explicit protocols for issue management and resolution.
5. Better cost management: By specifying the level of service that the customer can anticipate and providing a way to track and evaluate performance, SLAs can help to limit costs. Making sure the consumer is getting the best value for their money can be made easier by doing this.

Disadvantages of SLA

1. Complexity: SLAs can be complex to create and maintain, and may require significant resources to implement and enforce.
2. Rigidity: SLAs can be rigid and may not be flexible enough to accommodate changing business needs or service requirements.

3. Limited service options: SLAs can limit the service options available to the customer, as the service provider may only be able to offer the specific services outlined in the agreement.
4. Misaligned incentives: SLAs may misalign incentives between the service provider and the customer, as the provider may focus on meeting the agreed-upon service levels rather than on providing the best service possible.
5. Limited liability: SLAs are not legal binding contracts and often limited the liability of the service provider in case of service failure.

Identity and Access Management

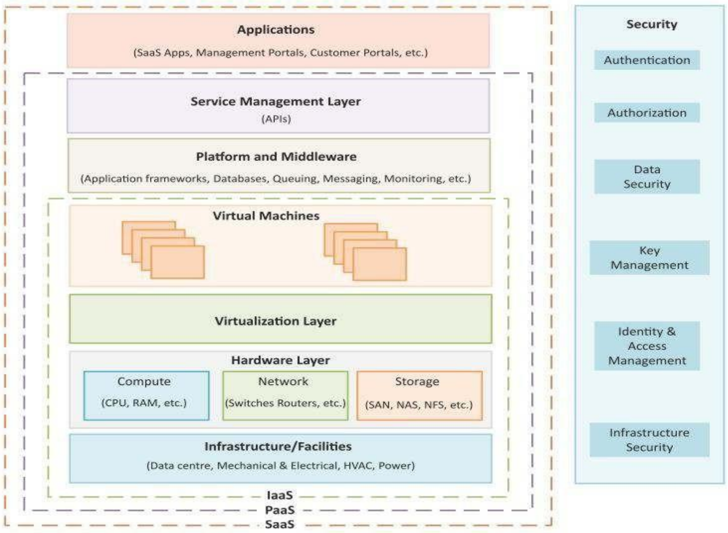
- Identity and Access Management (IDAM) for cloud describes the authentication and authorization of users to provide secure access to cloud resources.
- Organizations with multiple users can use IDAM services provided by the cloud service provider for management of user identifiers and user permissions.
- IDAM services allow organizations to centrally manage users, access permissions, security credentials and access keys.
- Organizations can enable role-based access control to cloud resources and applications using the IDAM services.
- IDAM services allow creation of user groups where all the users in a group have the same access permissions.
- Identity and Access Management is enabled by a number of technologies such as OpenAuth, Role-based Access Control (RBAC), Digital Identities, Security Tokens, Identity Providers, etc.

Billing

Cloud service providers offer a number of billing models described as follows:

- Elastic Pricing
  - In elastic pricing or pay-as-you-use pricing model, the customers are charged based on the usage of cloud resources.
- Fixed Pricing
  - In fixed pricing models, customers are charged a fixed amount per month for the cloud resources.
- Spot Pricing
  - Spot pricing models offer variable pricing for cloud resources which is driven by market demand.

Cloud Services & Platforms Cloud Reference Model:



- Infrastructure & Facilities Layer: Includes the physical infrastructure such as datacenter facilities, electrical and mechanical equipment, etc.
- Hardware Layer: Includes physical compute, network and storage hardware.
- Virtualization Layer: Partitions the physical hardware resources into multiple virtual resources that enabling pooling of resources.
- Platform & Middleware Layer: Builds upon the IaaS layers below and provides standardized stacks ofservices such as database service, queuing service, application frameworksand run-time environments, messaging services, monitoring services, analytics services, etc.
- Service Management Layer: Provides APIs for requesting, managing and monitoring cloud resources.
- Applications Layer: Includes SaaS applications such as Email, cloud storage application, productivity applications, management portals, customer self-service portals, etc.

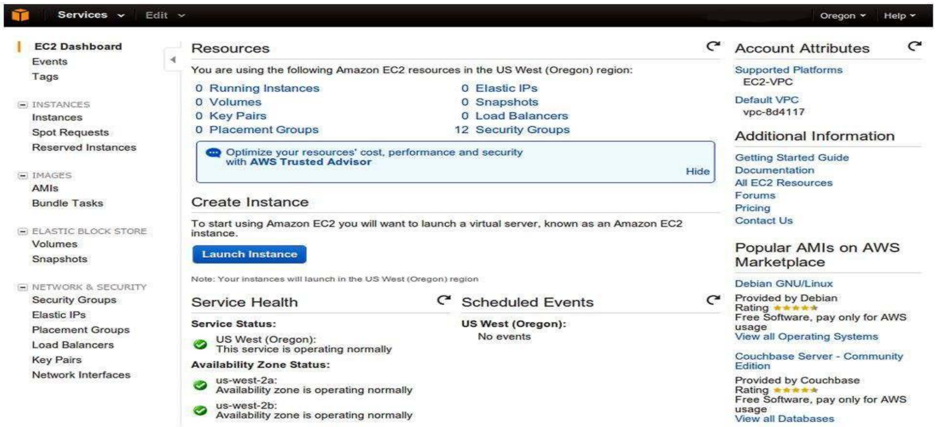
Compute Services

- Compute services provide dynamically scalable compute capacity in the cloud.
- Compute resources can be provisioned on-demand in the form of virtual machines. Virtual machines can be created from standard images provided by the cloud service provider or custom images created by the users.
- Compute services can be accessed from the web consoles of these services that provide graphical user interfaces for provisioning, managing and monitoring these services.
- Cloud service providers also provide APIs for various programming languages that allow developers to access and manage these services programmatically.

Compute Services – Amazon EC2

Amazon Elastic Compute Cloud (EC2) is a compute service provided by Amazon.

- Launching EC2 Instances: To launch a new instance click on the launch instance button. This will open a wizard where you can select the Amazon machine image (AMI) with which you want to launch the instance. You can also create their own AMIs with custom applications, libraries and data. Instances can be launched with a variety of operating systems.
- Instance Sizes: When you launch an instance you specify the instance type (micro, small, medium, large, extra-large, etc.), the number of instances to launch based on the selected AMI and availability zones for the instances.
- Key-pairs: When launching a new instance, the user selects a key-pair from existing keypairs or creates a new keypair for the instance. Keypairs are used to securely connect to an instance after it launches.
- Security Groups: The security groups to be associated with the instance can be selected from the instance launch wizard. Security groups are used to open or block a specific network port for the launched instances.



Resources

You are using the following Amazon EC2 resources in the US West (Oregon) region:

0 Running Instances
0 Volumes
0 Key Pairs
0 Placement Groups
0 Elastic IPs
0 Snapshots
0 Load Balancers
12 Security Groups

Optimize your resources' cost, performance and security with **AWS Trusted Advisor**

Create Instance

To start using Amazon EC2 you will want to launch a virtual server, known as an Amazon EC2 instance.

Note: Your instances will launch in the US West (Oregon) region

Service Health

Service Status:

US West (Oregon):
This service is operating normally

Availability Zone Status:

us-west-2a:
Availability zone is operating normally

us-west-2b:
Availability zone is operating normally

Scheduled Events

US West (Oregon):
No events

Account Attributes

Supported Platforms
EC2-VPC

Default VPC
vpc-8d4117

Additional Information

Getting Started Guide
Documentation
All EC2 Resources
Forums
Pricing
Contact Us

Popular AMIs on AWS Marketplace

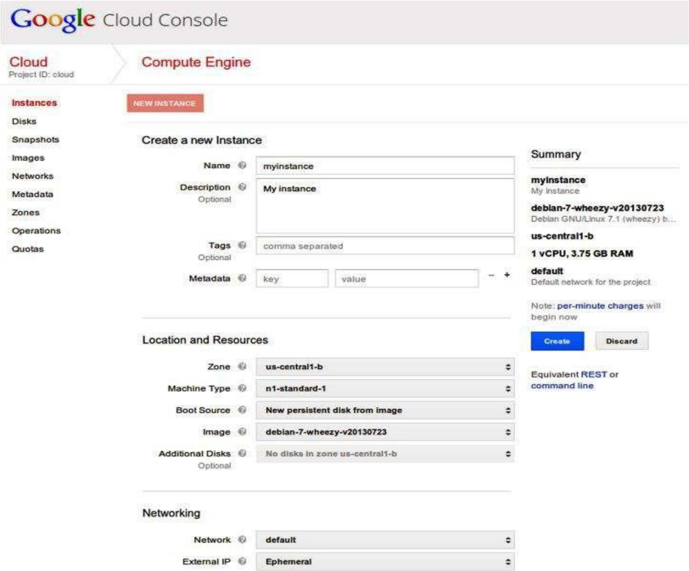
Debian GNU/Linux
Provided by Debian
Rating ★★★★★
Free Software, pay only for AWS usage
View all Operating Systems

Couchbase Server - Community Edition
Provided by Couchbase
Rating ★★★★★
Free Software, pay only for AWS usage
View all Databases

Compute Services – Google Compute Engine

Google Compute Engine is a compute service provided by Google.

- Launching Instances: To create a new instance, the user selects an instance machine type, a zone in which the instance will be launched, a machine image for the instance and provides an instance name, instance tags and meta-data.
- Disk Resources: Every instance is launched with a disk resource. Depending on the instance type, the disk resource can be a scratch disk space or persistent disk space. The scratch disk space is deletedwhen the instance terminates. Whereas, persistent disks live beyond the life of an instance.
- Network Options: Network option allows you to control the traffic to and from the instances. By default, traffic between instances in the same network, over any port and any protocol and incoming SSH connections from anywhere are enabled.



Create a new Instance

Name: myinstance

Description (Optional): My instance

Tags (Optional): comma separated

Metadata: key value

Location and Resources

Zone: us-central1-b

Machine Type: n1-standard-1

Boot Source: New persistent disk from image

Image: debian-7-wheezy-v20130723

Additional Disks (Optional): No disks in zone us-central1-b

Networking

Network: default

External IP: Ephemeral

Summary

myinstance
My instance

debian-7-wheezy-v20130723
Debian GNU/Linux 7.1 (wheezy) b...

us-central1-b

1 vCPU, 3.75 GB RAM

default
Default network for the project

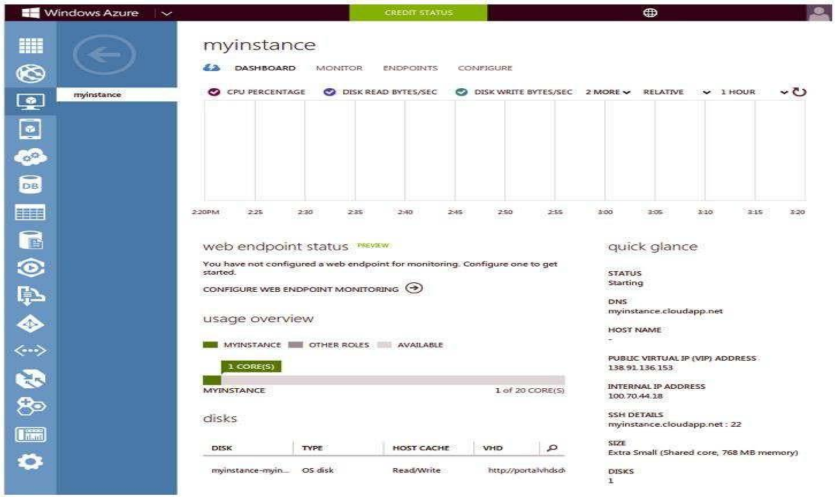
Note: per-minute charges will begin now

Equivalent REST or command line

Compute Services – Windows Azure VMs

Windows Azure Virtual Machines is the compute service from Microsoft.

- Launching Instances:
  - To create a new instance, you select the instance type and the machine image.
  - You can either provide a user name and password or upload a certificate file for securely connecting to the instance.
  - Any changes made to the VM are persistently stored and new VMs can be created from the previously stored machine images.



myinstance

web endpoint status

You have not configured a web endpoint for monitoring. Configure one to get started.

usage overview

MYINSTANCE 1 of 20 CORE(S)

disks

DISK	TYPE	HOST CACHE	VHD
myinstance-myin...	OS disk	Read/Write	http://portalvhdsd

quick glance

STATUS
Starting

DNS
myinstance.cloudapp.net

HOST NAME
-

PUBLIC VIRTUAL IP (VIP) ADDRESS
138.91.136.153

INTERNAL IP ADDRESS
100.70.44.18

SSH DETAILS
myinstance.cloudapp.net : 22

SIZE
Extra Small (Shared core, 768 MB memory)

DISKS
1

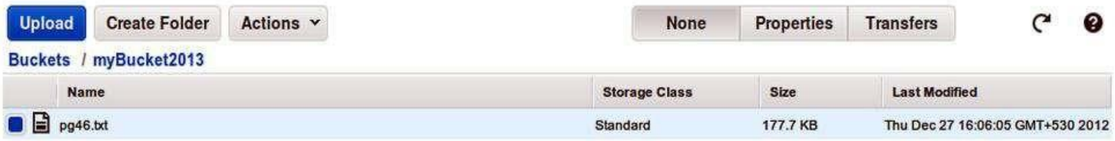
Storage Services

- Cloud storage services allow storage and retrieval of any amount of data, at any time from anywhere on the web.
- Most cloud storage services organize data into buckets or containers.
- Scalability

  - Cloud storage services provide high capacity and scalability. Objects upto several tera-bytes in size can be uploaded and multiple buckets/containers can be created on cloud storages.
- Replication
  - When an object is uploaded it is replicated at multiple facilities and/or on multiple devices within each facility.
- Access Policies
  - Cloud storage services provide several security features such as Access Control Lists (ACLs), bucket/container level policies, etc. ACLs can be used to selectively grant access permissions on individual objects. Bucket/container level policies can also be defined to allow or deny permissions across some or all of the objects within a single bucket/container.
- Encryption
  - Cloud storage services provide Server Side Encryption (SSE) options to encrypt all data stored in the cloud storage.
- Consistency
  - Strong data consistency is provided for all upload and delete operations. Therefore, any object that is uploaded can be immediately downloaded after the upload is complete.

Storage Services – Amazon S3

- Amazon Simple Storage Service(S3) is an online cloud-based data storage infrastructure for storing and retrieving any amount of data.
- S3 provides highly reliable, scalable, fast, fully redundant and affordable storage infrastructure.
- Buckets
  - Data stored on S3 is organized in the form of buckets. You must create a bucket before you can store data on S3.
- Uploading Files to Buckets
  - S3 console provides simple wizards for creating a new bucket and uploading files.
  - You can upload any kind of file to S3.
  - While uploading a file, you can specify the redundancy and encryption options and access permissions.



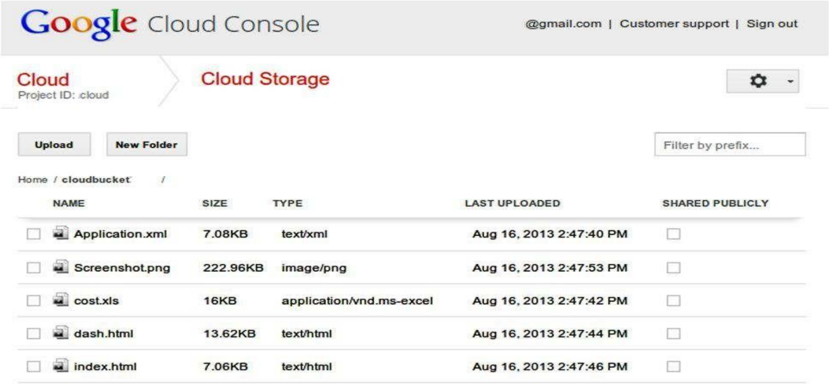
Buckets / myBucket2013

Name	Storage Class	Size	Last Modified
pg46.txt	Standard	177.7 KB	Thu Dec 27 16:06:05 GMT+530 2012

Storage Services – Google Cloud Storage

- GCS is the Cloud storage service from Google
- Buckets
  - Objects in GCS are organized into buckets.
  - Access Control Lists

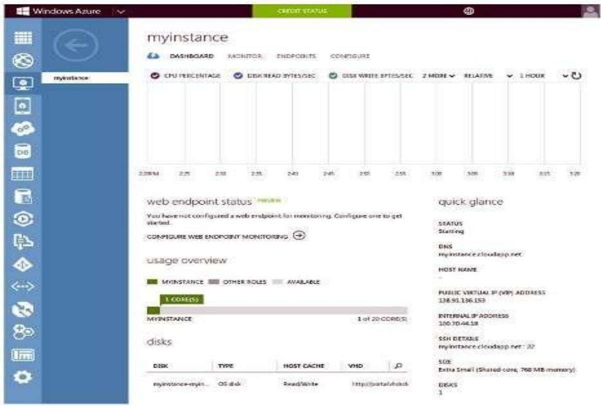
- ACLs are used to control access to objects and buckets.
- ACLs can be configured to share objects and buckets with the entire world, a Google group, a Google-hosted domain, or specific Google account holders.



NAME	SIZE	TYPE	LAST UPLOADED	SHARED PUBLICLY
□ Application.xml	7.08KB	text/xml	Aug 16, 2013 2:47:40 PM	□
□ Screenshot.png	222.96KB	image/png	Aug 16, 2013 2:47:53 PM	□
□ cost.xls	16KB	application/vnd.ms-excel	Aug 16, 2013 2:47:42 PM	□
□ dash.html	13.62KB	text/html	Aug 16, 2013 2:47:44 PM	□
□ index.html	7.06KB	text/html	Aug 16, 2013 2:47:46 PM	□

Storage Services – Windows Azure Storage

- Windows Azure Storage is the cloud storage service from Microsoft.
- Windows Azure Storage provides various storage services such as blob storage service, table service and queue service.
- Blob storage service
  - The blob storage service allows storing unstructured binary data or binary large objects (blobs).
  - Blobs are organized into containers.
  - Block blobs - can be subdivided into some number of blocks. If a failure occurs while transferring a block blob, retransmission can resume with the most recent block rather than sending the entire blob again.
  - Page blobs - are divided into number of pages and are designed for random access. Applications can read and write individual pages at random in a page blob.



myinstance

You have not configured a web endpoint for monitoring. Configure one to get started.

CONFIGURE WEB ENDPOINT MONITORING

MYINSTANCE 1 of 20 CORE(S)

DISK	TYPE	HOST CACHE	VHD
myinstance-myin...	OS disk	Read/Write	http://portalvhdsd

STATUS
Starting

DNS
myinstance.cloudapp.net

HOST NAME
-

PUBLIC VIRTUAL IP (VIP) ADDRESS
138.91.136.153

INTERNAL IP ADDRESS
100.70.46.18

SSH DETAILS
myinstance.cloudapp.net : 22

SIZE
Extra Small (Shared core, 768 MB memory)

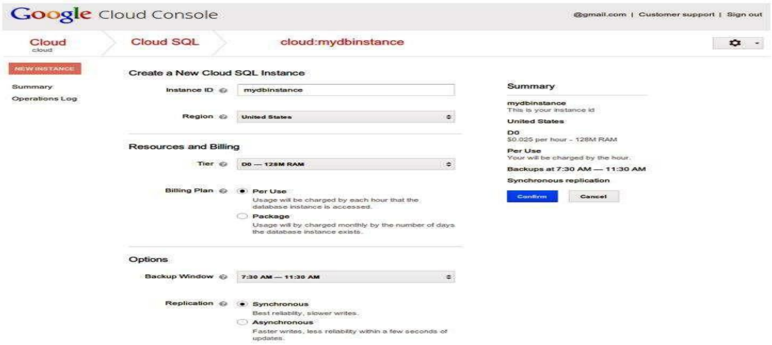
DISKS
1

Storage Services – Google Cloud SQL

- Google SQL is the relational database service from Google.
- Google Cloud SQL service allows you to host MySQL databases in the

Google’s cloud.

- Launching DB Instances
  - You can create new database instances from the console and manage existing instances. To create a new instance you select a region, database tier, billing plan and replication mode.
- Backups
  - You can schedule daily backups for your Google Cloud SQL instances, and also restore backed-up databases.
- Replication
  - Cloud SQL provides both synchronous or asynchronous geographic replication and the ability to import/ export databases.



Create a New Cloud SQL Instance

Instance ID: mydbinstance

Region: United States

Resources and Billing

Tier: D0 — 128M RAM

Billing Plan:
● Per Use
Usage will be charged by each hour that the database instance is accessed.
○ Package
Usage will by charged monthly by the number of days the database instance exists.

Options

Backup Window: 7:30 AM — 11:30 AM

Replication:
● Synchronous
Best reliablity, slower writes.
○ Asynchronous
Faster writes, less reliabilty within a few seconds of updates.

Summary

mydbinstance
This is your instance id

United States

D0
$0.025 per hour - 128M RAM

Per Use
Your will be charged by the hour.

Backups at 7:30 AM — 11:30 AM

Synchronous replication

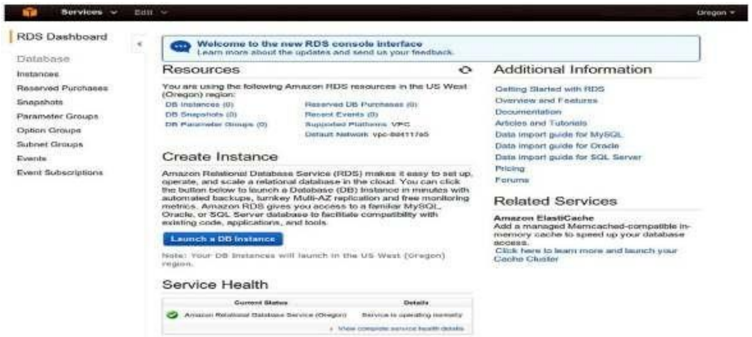
Database Services

Cloud database services allow you to set-up and operate relational or non-relational databases in the cloud.

- Relational Databases:Popular relational databases provided by various cloud service providers include MySQL, Oracle, SQL Server, etc.
- Non-relational Databases:The non-relational (No-SQL) databases provided by cloud service providers are mostly proprietary solutions.
- Scalability:Cloud database services allow provisioning as much compute and storage resources as required to meet the application workload levels. Provisioned capacity can be scaled-up or down. For read-heavy workloads, read-replicas can be created.
- Reliability:Cloud database services are reliable and provide automated backup and snapshot options.
- Performance:Cloud database services provide guaranteed performance with options such as guaranteed input/output operations per second (IOPS) which can be provisioned upfront.
- Security:Cloud database services provide several security features to restrict the access to the database instances and stored data, such as network firewalls and authentication mechanisms.

Database Services – Amazon RDS

- Amazon Relational Database Service (RDS) is a web service that makes it easy to setup, operate and scale a relational database in the cloud.
- Launching DB Instances
  - The console provides an instance launch wizard that allows you to select the type of database to create (MySQL, Oracle or SQL Server) database instance size, allocated storage, DB instance identifier, DB username and password. The status of the launched DB instances can be viewed from the console.
- Connecting to a DB Instance
  - Once the instance is available, you can note the instance end point from the instance properties tab. This end point can then be used for securely connecting to the instance.



Welcome to the new RDS console interface
Learn more about the updates and send us your feedback.

Resources

You are using the following Amazon RDS resources in the US West (Oregon) region:

DB Instances (0)
DB Snapshots (0)
DB Parameter Groups (0)
Reserved DB Purchases (0)
Recent Events (0)
Supported Platforms VPC
Default Network vpc-8d411765

Create Instance

Amazon Relational Database Service (RDS) makes it easy to set up, operate, and scale a relational database in the cloud. You can click the button below to launch a Database (DB) Instance in minutes with automated backups, turnkey Multi-AZ replication and free monitoring metrics. Amazon RDS gives you access to a familiar MySQL, Oracle, or SQL Server database to facilitate compatibility with existing code, applications, and tools.

Note: Your DB Instances will launch in the US West (Oregon) region.

Service Health

Current Status	Details
✓ Amazon Relational Database Service (Oregon)	Service is operating normally

View complete service health details

Additional Information

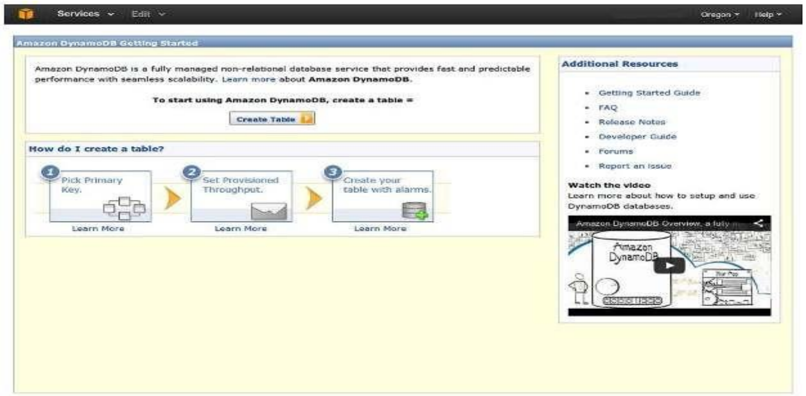
Getting Started with RDS
Overview and Features
Documentation
Articles and Tutorials
Data import guide for MySQL
Data import guide for Oracle
Data import guide for SQL Server
Pricing
Forums

Related Services

Amazon ElastiCache
Add a managed Memcached-compatible in-memory cache to speed up your database access.
Click here to learn more and launch your Cache Cluster

Database Services – Amazon DynamoDB

- Amazon DynamoDB is the non-relational (No-SQL) database service from Amazon.
- Data Model
  - The DynamoDB data model includes include tables, items and attributes.
  - A table is a collection of items and each item is a collection of attributes.
  - To store data in DynamoDB you have to create a one or more tables and specify how much throughput capacity you want to provision and reserve for reads and writes.
- Fully Managed Service
  - DynamoDB is a fully managed service that automatically spreads the data and traffic for the stored tables over a number of servers to meet the throughput requirements specified by the users.
- Replication
  - All stored data is automatically replicated across multiple availability zones to provide data durability.



Amazon DynamoDB Getting Started

Amazon DynamoDB is a fully managed non-relational database service that provides fast and predictable performance with seamless scalability. Learn more about **Amazon DynamoDB**.

To start using Amazon DynamoDB, create a table =

Create Table

How do I create a table?

1. Pick Primary Key. Learn More
2. Set Provisioned Throughput. Learn More
3. Create your table with alarms. Learn More

Additional Resources

- Getting Started Guide
- FAQ
- Release Notes
- Developer Guide
- Forums
- Report an Issue

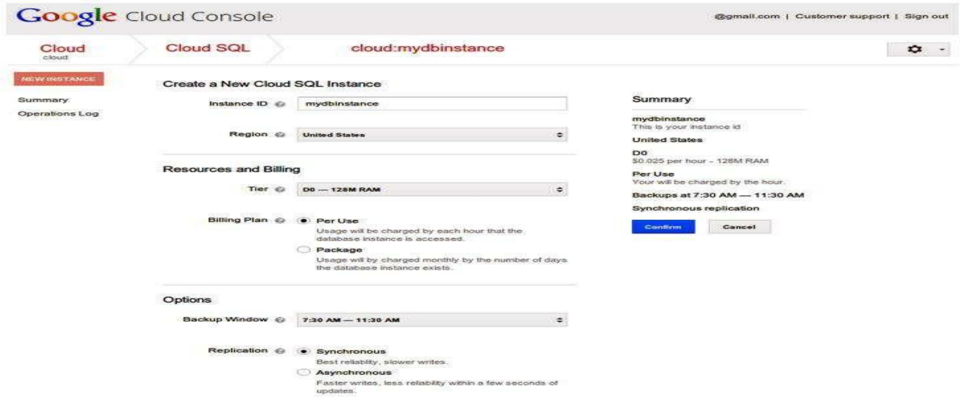
Watch the video

Learn more about how to setup and use DynamoDB databases.

Storage Services – Google Cloud SQL

- Google SQL is the relational database service from Google.
- Google Cloud SQL service allows you to host MySQL databases in the Google's cloud.
- Launching DB Instances
  - You can create new database instances from the console and manage existing instances. To create a new instance you select a region, database tier, billing plan and replication mode.
- Backups
  - You can schedule daily backups for your Google Cloud SQL instances, and also restore backed-up databases.
- Replication

Cloud SQL provides both synchronous or asynchronous geographic replication and the ability to import/ export databases.



Create a New Cloud SQL Instance

Instance ID: mydbinstance

Region: United States

Resources and Billing

Tier: D0 — 128M RAM

Billing Plan: ● Per Use
Usage will be charged by each hour that the database instance is accessed.
○ Package
Usage will by charged monthly by the number of days the database instance exists.

Options

Backup Window: 7:30 AM — 11:30 AM

Replication: ● Synchronous
Best reliablity, slower writes.
○ Asynchronous
Faster writes, less reliablity within a few seconds of updates.

Summary

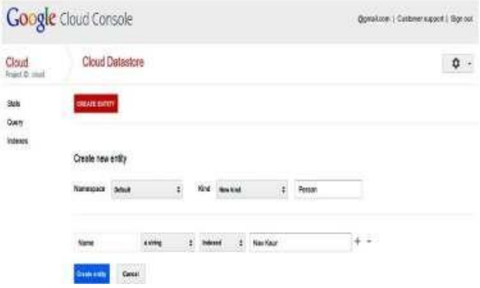
mydbinstance
This is your instance id
United States
D0
$0.025 per hour - 128M RAM
Per Use
Your will be charged by the hour.
Backups at 7:30 AM — 11:30 AM
Synchronous replication

Confirm Cancel

Storage Services – Google Cloud Datastore

- Google Cloud Datastore is a fully managed non-relational database from Google.
- Cloud Datastore offers ACID transactions and high availability of reads and writes.
- Data Model
  - The Cloud Datastore data model consists of entities. Each entity has one or more properties (key-value pairs) which can be of one of several supported data types, such as strings and integers. Each entity has a kind

and a key. The entity kind is used for categorizing the entity for the purpose of queries and the entity key uniquely identifies the entity.



Create new entity

Namespace Default Kind New kind Person

Name a string Indexed Nav Kaur

Storage Services – Windows Azure Table Service

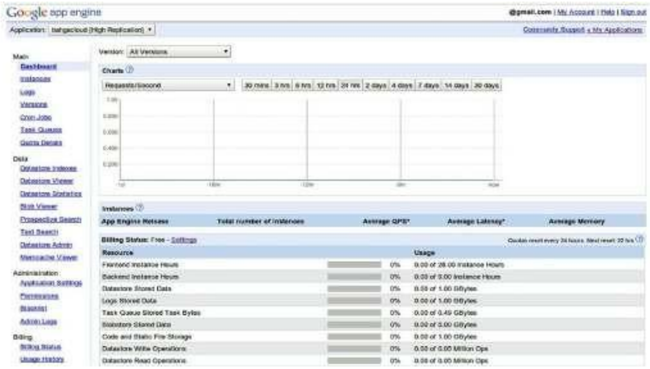
- Windows Azure Table Service is a non-relational (No-SQL) database service from Microsoft.
- Data Model
    - The Azure Table Service data model consists of tables having multiple entities.
    - Tables are divided into some number of partitions, each of which can be stored on a separate machine.
    - Each partition in a table holds a specified number of entities, each containing as many as 255 properties.
    - Each property can be one of the several supported data types such as integers and strings.
    - No Fixed Schema
    - Tables do not have a fixed schema and different entities in a table can have different properties.

Application Runtimes & Frameworks

- Cloud-based application runtimes and frameworks allow developers to develop and host applications in the cloud.
- Support for various programming languages
    - Application runtimes provide support for programming languages (e.g., Java, Python, or Ruby).
    - Resource Allocation
    - Application runtimes automatically allocate resources for applications and handle the application scaling, without the need to run and maintain servers.

Google App Engine

- Google App Engine is the platform-as-a-service (PaaS) from Google, which includes both an application runtime and web frameworks.
- Runtimes
  - App Engine provides runtime environments for Java, Python, PHP and Go programming language.
- Sandbox
  - Applications run in a secure sandbox environment isolated from other applications.
  - The sandbox environment provides a limited access to the underlying operating system.
- Web Frameworks
  - App Engine provides a simple Python web application framework called webapp2. App Engine also supports any framework written in pure Python that speaks WSGI, including Django, CherryPy, Pylons, web.py, and web2py.
- Datastore
  - App Engine provides a no-SQL data storage service.
- Authentication
  - App Engine applications can be integrated with Google Accounts for user authentication.
- URL Fetch service
  - URL Fetch service allows applications to access resources on the Internet, such as web services or other data.
- Other services
  - Email service
  - Image Manipulation service
  - Memcache
  - Task Queues



Application: bahgacloud (High Replication)

Version: All Versions

Requests/Second

App Engine Release	Total number of instances	Average QPS*	Average Latency*	Average Memory

Billing Status: Free - Settings

Quotas reset every 24 hours. Next reset: 22 hrs

Resource		Usage
Frontend Instance Hours	0%	0.00 of 28.00 Instance Hours
Backend Instance Hours	0%	0.00 of 9.00 Instance Hours
Datastore Stored Data	0%	0.00 of 1.00 GBytes
Logs Stored Data	0%	0.00 of 1.00 GBytes
Task Queue Stored Task Bytes	0%	0.00 of 0.49 GBytes
Blobstore Stored Data	0%	0.00 of 5.00 GBytes
Code and Static File Storage	0%	0.00 of 1.00 GBytes
Datastore Write Operations	0%	0.00 of 0.05 Million Ops
Datastore Read Operations	0%	0.00 of 0.05 Million Ops

Scheduled Tasks service

Windows Azure Web Sites

- Windows Azure Web Sites is a Platform-as-a-Service (PaaS) from Microsoft.
- Azure Web Sites allows you to host web applications in the Azure cloud.
- Shared & Standard Options.

  - In the shared option, Azure Web Sites run on a set of virtual machines that may contain multiple web sites created by multiple users.
  - In the standard option, Azure Web Sites run on virtual machines (VMs) that belong to an individual user.

- Azure Web Sites supports applications created in ASP.NET, PHP, Node.js and Python programming languages.
- Multiple copies of an application can be run in different VMs, with Web Sites automatically load balancing requests across them.

Content Delivery Services

- Cloud-based content delivery service include Content Delivery Networks (CDNs).
- CDN is a distributed system of servers located across multiple geographic locations to serve content to end- users with high availability and high performance.
- CDNs are useful for serving static content such as text, images, scripts, etc., and streaming media.
- CDNs have a number of edge locations deployed in multiple locations, often over multiple backbones.
- Requests for static for streaming media content that is served by a CDN are directed to the nearest edge location.
- Amazon CloudFront
  - Amazon CloudFront is a content delivery service from Amazon. CloudFront can be used to deliver dynamic, static and streaming content using a global network of edge locations.
- Windows Azure Content Delivery Network
  - Windows Azure Content Delivery Network (CDN) is the content delivery service from Microsoft.

Analytics Services

- Cloud-based analytics services allow analyzing massive data sets stored in the cloud either in cloud storages or in cloud databases using programming models such as MapReduce.
- Amazon Elastic MapReduce
  - Amazon Elastic MapReduce is the MapReduce service from Amazon based the Hadoop framework running on Amazon EC2 and S3
  - EMR supports various job types such as Custom JAR, Hive program, Streaming job, Pig programs and Hbase
- Google MapReduce Service

    - Google MapReduce Service is a part of the App Engine platform and can be accessed using the Google MapReduce API.
- Google BigQuery
    - Google BigQuery is a service for querying massive datasets. BigQuery allows querying datasets using SQL-like queries.
- Windows Azure HDInsight
    - Windows Azure HDInsight is an analytics service from Microsoft. HDInsight deploys and provisions Hadoop clusters in the Azure cloud and makes Hadoop available as a service.

Deployment & Management Services

- Cloud-based deployment & management services allow you to easily deploy and manage applications in the cloud. These services automatically handle deployment tasks such as capacity provisioning, load balancing, auto-scaling, and application health monitoring.
- Amazon Elastic Beanstalk
    - Amazon provides a deployment service called Elastic Beanstalk that allows you to quickly deploy and manage applications in the AWS cloud.
    - Elastic Beanstalk supports Java, PHP, .NET, Node.js, Python, and Ruby applications.
    - With Elastic Beanstalk you just need to upload the application and specify configuration settings in a simple wizard and the service automatically handles instance provisioning, server configuration, load balancing and monitoring.
- Amazon CloudFormation
    - Amazon CloudFormation is a deployment management service from Amazon.
    - With CloudFront you can create deployments from a collection of AWS resources such as Amazon Elastic Compute Cloud, Amazon Elastic Block Store, Amazon Simple Notification Service, Elastic Load Balancing and Auto Scaling.
    - A collection of AWS resources that you want to manage together are organized into a stack.

Identity & Access Management Services

- Identity & Access Management (IDAM) services allow managing the authentication and authorization of users to provide secure access to cloud resources.
- Using IDAM services you can manage user identifiers, user permissions, security

credentials and access keys.

- Amazon Identity & Access Management
    - AWS Identity and Access Management (IAM) allows you to manage users and user permissions for an AWS account.
    - With IAM you can manage users, security credentials such as access keys, and permissions that control which AWS resources users can access.
    - Using IAM you can control what data users can access and what resources users can create.
    - IAM also allows you to control creation, rotation, and revocation security credentials of users.

Open Source Private Cloud Software – CloudStack

- Apache CloudStack is an open source cloud software that can be used for creating private cloud offerings.
- CloudStack manages the network, storage, and compute nodes that make up a cloud infrastructure.
- A CloudStack installation consists of a Management Server and the cloud infrastructure that it manages.
- Zones : The Management Server manages one or more zones where each zone is typically a single datacenter.
- Pods : Each zone has one or more pods. A pod is a rack of hardware comprising of a switch and one or more clusters.
- Cluster: A cluster consists of one or more hosts and a primary storage. A host is a compute node that runs guest virtual machines.
- Primary Storage: The primary storage of a cluster stores the disk volumes for all the virtual machines running on the hosts in that cluster.
- Secondary Storage: Each zone has a secondary storage that stores templates, ISO images, and disk volume snapshots.

Open Source Private Cloud Software –Eucalyptus

Eucalyptus is an open source private cloud software for building private and hybrid clouds that are compatible with Amazon Web Services (AWS) APIs.

- Node Controller
    - NC hosts the virtual machine instances and manages the virtual network endpoints.
- The cluster-level (availability-zone) consists of three components
    - Cluster Controller - which manages the virtual machines and is the front-end for a cluster.
    - Storage Controller — which manages the Eucalyptus block volumes and snapshots to the instances within its specific cluster. SC is equivalent to

  AWS Elastic Block Store (EBS).
  - VMWare Broker - which is an optional component that provides an AWS-compatible interface for VMware environments.
- At the cloud-level there are two components:

  - Cloud Controller - which provides an administrative interface for cloud management and performs high-level resource scheduling, system accounting, authentication and quota management.
  - Walrus - which is equivalent to Amazon S3 and serves as a persistent storage to all of the virtual machines in the Eucalyptus cloud. Walrus can be used as a simple Storage-as-a-Service.