

CLOUD COMPUTING

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SPPU New Syllabus

A Book Of

Cloud Computing

B.C.A. (Science) : Semester - V

[Course Code BCA - 355 : Credits-02]

CBCS Pattern

As Per New Syllabus, Effective from June 2021-22

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Preface ...

We take this opportunity to present this book entitled as "**Cloud Computing**" to the students of Fifth Semester - BCA (Science). The object of this book is to present the subject matter in a most concise and simple manner. The book is written strictly according to the New Syllabus (CBCS Pattern).

The book covers theory of Introduction to Cloud Computing, Abstraction and Virtualization, Programming Environment, Deploying Applications and Cloud Services, Emerging Trends in Cloud Computing, Security in the Cloud.

The book has its own unique features. It brings out the subject in a very simple and lucid manner for easy and comprehensive understanding of the basic concepts, its intricacies, procedures and practices. This book will help the readers to have a broader view on Cloud Computing. The language used in this book is easy and will help students to improve their vocabulary of Technical terms and understand the matter in a better and happier way.

We sincerely thank Shri. Dineshbhai Furia and Shri. Jignesh Furia of Nirali Prakashan, for the confidence reposed in us and giving us this opportunity to reach out to the students.

We also thank Mrs. Prachi Sawant, Mrs. Anita Panajkar, Mrs. Prajakta Waghmare and Mr. Ravindra Walodare of M/s Nirali Prakashan for their excellent co-operation.

We have given our best inputs for this book. Any suggestions towards the improvement of this book and sincere comments are most welcome on niralipune@pragationline.com.

Authors

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1...

Introduction to Cloud Computing

Learning Objectives ...

- To learn about cloud computing and its technologies, architectures, and applications.
- To have a better understanding of the difficulties that arise while deploying and implementing applications in the cloud.
- To have a better understanding of cloud computing's most recent trends.

1.1 OVERVIEW OF CLOUD

1.1.1 What is Cloud ?

- The "cloud" refers to servers that are accessed over the Internet, software and databases that run on those servers. Cloud servers are located in data centers all over the world. By using cloud computing, users and companies don't have to manage physical servers themselves or run software applications on their own machines.

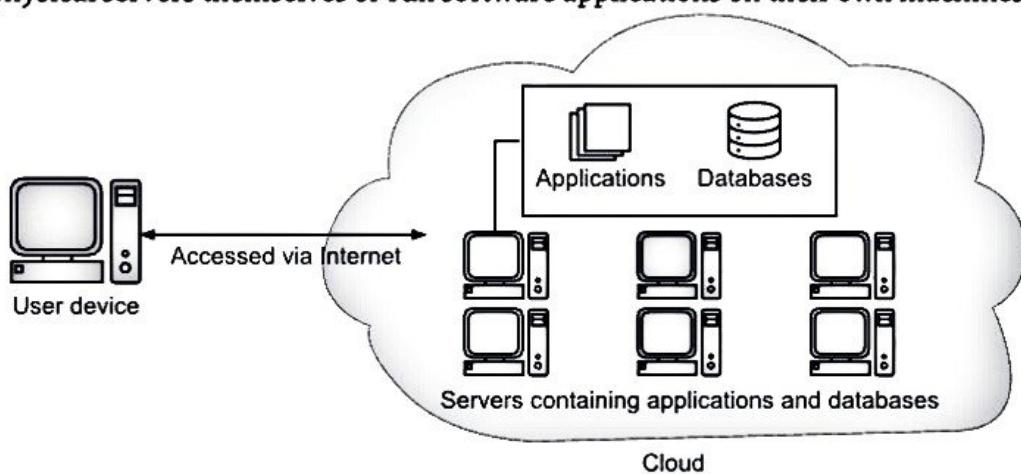


Fig. 1.1: Cloud

(1.1)

- The cloud enables users to access the same files and applications from almost any device because the computing and storage take place on servers in a data center, instead of locally on the user device. This is why a user can log into their Instagram account on a new phone after their old phone breaks and still find their old account in place, with all their photos, videos, and conversation history. It works the same way with cloud email providers like Gmail or Microsoft Office 365, and with cloud storage providers like Dropbox or Google Drive.
- For businesses, switching to cloud computing removes some IT costs and overhead. For example, they no longer need to update and maintain their own servers, as the cloud vendor they are using will do that. This especially makes an impact for small businesses that may not have been able to afford their own internal infrastructure but can outsource their infrastructure needs affordably via the cloud. The cloud can also make it easier for companies to operate internationally, because employees and customers can access the same files and applications from any location.
- Cloud computing may operate on both public and private networks, such as WANs, LANs, and VPNs. Email, online conferencing, and Customer Relationship Management (CRM) are just a few examples of cloud-based applications.

1.1.2 What is Cloud Computing?

- Cloud computing transforms IT infrastructure into a utility. It lets you 'plug in' to infrastructure via the internet and use computing resources without installing and maintaining them on-premises.
- Cloud computing is on-demand access, via the internet to computing resources applications, servers, data storage, development tools, networking capabilities, and more hosted at a remote data center managed by a Cloud Services Provider (or CSP). The CSP makes these resources available for a monthly subscription fee or bills them according to usage.
- Compared to traditional IT and depending on the cloud services you select, cloud computing helps do the following:
 - **Lower IT costs:** Cloud lets you offload some or most of the costs and effort of purchasing, installing, configuring, and managing your own on-premises infrastructure.
 - **Improve agility and time-to-value:** With cloud, your organization can start using enterprise applications in minutes, instead of waiting weeks or months for IT to respond to a request, purchase and configure supporting hardware, and install software. To help themselves to software and support infrastructure, cloud also lets you empower certain users specifically developers and data scientists.

- **Scale more easily and cost-effectively:** Cloud provides elasticity instead of purchasing excess capacity that sits unused during slow periods; you can scale capacity up and down in response to spikes and dips in traffic. You can also take advantage of your cloud provider's global network to spread your applications closer to users around the world.
- The term 'cloud computing' also refers to the technology that makes cloud work. This includes some form of virtualized IT infrastructure servers, operating system software, networking, and other infrastructure that's abstracted, using special software, so that it can be pooled and divided irrespective of physical hardware boundaries. For example, a single hardware server can be divided into multiple virtual servers.
- Virtualization enables cloud providers to make maximum use of their data center resources. Not surprisingly, many corporations have adopted the cloud delivery model for their on-premises infrastructure so they can realize maximum utilization and cost savings vs. traditional IT infrastructure and offer the same self-service and agility to their end-users.
- If you use a computer or mobile device at home or at work, you almost certainly use some form of cloud computing every day, whether it's a cloud application like Google Gmail or Salesforce, streaming media like Netflix, or cloud file storage like Dropbox. According to a recent survey, 92% of organizations use cloud today , and most of them plan to use it more within the next year.

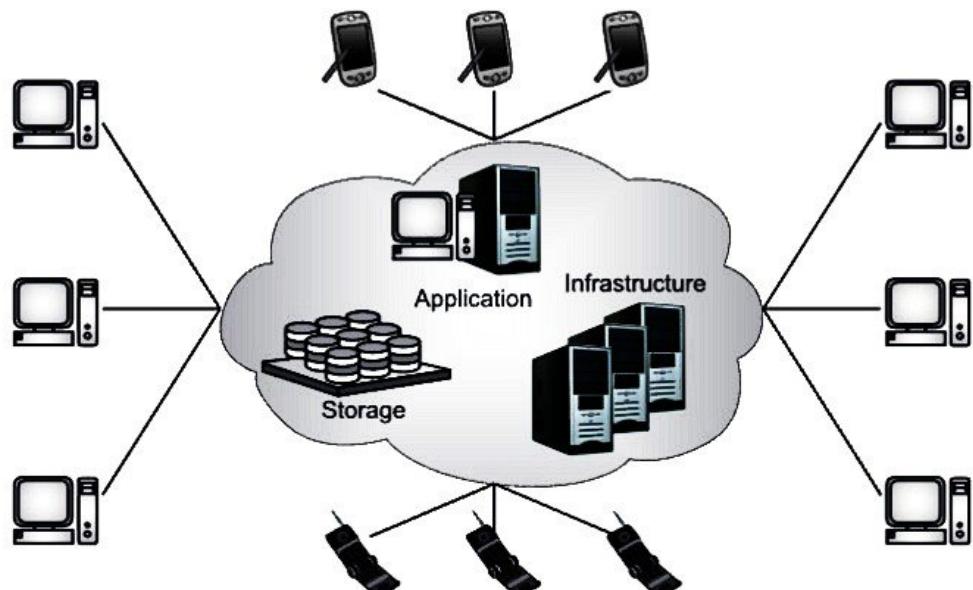


Fig. 1.2: Cloud Computing

- Cloud computing refers to the process of remotely modifying, configuring, and accessing hardware and software resources. It provides data storage, infrastructure, and applications all across the internet.

How does cloud computing work?

- Cloud computing works by allowing client devices to access data over the internet, from remote servers, databases and computers.
- An internet network connection links the front end (includes the accessing client device, browser, network and cloud software applications) with the back end (which consists of databases, servers and computers). The back end functions as a repository, storing data that is accessed by the front end.
- Communications between the front and back ends are managed by a central server. The central server relies on protocols to facilitate the exchange of data. The central server uses both software and middleware to manage connectivity between different client devices and cloud servers. Typically, there will be a dedicated server for each individual application.

1.1.3 Cloud Computing Examples

- Examples of cloud computing include:
 - **Google Docs, Microsoft Office 365:** Users can access Google Docs and Microsoft Office 365 through the internet. Users can be more productive because they can access work presentations and spreadsheets stored in the cloud at any time from anywhere on any device.
 - **Email, Calendar, Skype, WhatsApp:** Emails, Calendars, Skype and WhatsApp take advantage of the cloud's ability to provide users with access to data remotely so they can access their personal data on any device, whenever and wherever they want.
 - **Zoom:** Zoom is a cloud-based software platform for video and audio conferencing that records meetings and saves them to the cloud, enabling users to access them anywhere and at any time.
 - **AWS Lambda:** Lambda allows developers to run code for applications or back end services without having to provision or manage servers. The pay-as-you-go model constantly scales with an organization to accommodate real-time changes in data usage and data storage.

1.2 TYPES OF CLOUD

- Deployment models specify the kind of cloud access, i.e. where the cloud is situated. The four forms of access to the cloud are public, private, hybrid, and community.

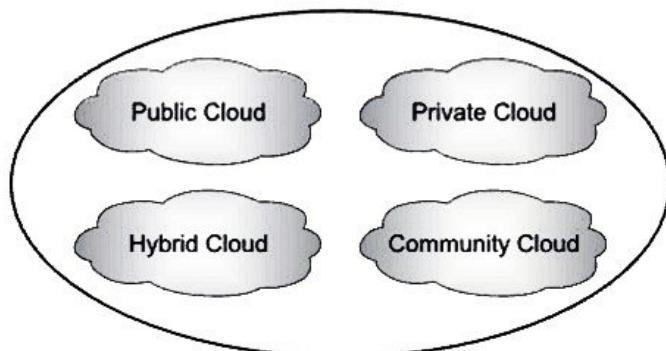


Fig. 1.3: Types of Cloud

1. Public Cloud

- The public cloud makes systems and services public to anybody with an internet connection. Because of its openness, the public cloud may be less secure.
- A public cloud environment is owned by an outsourced cloud provider and is accessible to many businesses through the internet on a pay-per-use model. This deployment model provides services and infrastructure to businesses who want to save money on IT operational costs, but it's the cloud provider who is responsible for the creation and maintenance of the resources.
- Public clouds are ideal for small and medium sized businesses with a tight budget requiring a quick and easy platform in which to deploy IT resources.
- **Pros of a public cloud:**
 - Easy scalability.
 - No geographical restrictions.
 - Cost effective.
 - Highly reliable.
 - Easy to manage.
- **Cons of a public cloud:**
 - Not considered the safest option for sensitive data.

2. Private Cloud

- Within a company, the private cloud allows systems and services to be accessed. Because of its private character, it is more secure.
- This cloud deployment model is a bespoke infrastructure owned by a single business. It offers a more controlled environment in which access to IT resources is more centralized within the business. This model can be externally hosted or can be managed in-house. Although private cloud hosting can be expensive, for larger businesses it can offer a higher level of security and more autonomy to customize the storage, networking and compute components to suit their IT requirements.

- **Pros of a private cloud:**
 - Improved level of security.
 - Greater control over the server.
 - Customizable.
- **Cons of a private cloud:**
 - Harder to access data from remote locations.
 - Requires IT expertise.

3. Community Cloud

- A collection of organizations can use the community cloud to access systems and services.
- Community cloud allows systems and services to be accessible by a group of several organizations to share the information between the organization and a specific community. It is owned, managed, and operated by one or more organizations in the community, a third party, or a combination of them.
- **Pros of a Community cloud:**
 - It provides better security than the public cloud.
 - It provides collaborative and distributive environment.
 - Community cloud allows us to share cloud resources, infrastructure and other capabilities among various organizations.
- **Cons of a Community cloud:**
 - Community cloud is not a good choice for every organization.
 - Security features are not as good as the private cloud.
 - It is not suitable if there is no collaboration.

4. Hybrid Cloud

- The hybrid cloud is a combination of public and private cloud, with important tasks being handled by private cloud and non-critical tasks handled by public cloud.
- For businesses seeking the benefits of both private and public cloud deployment models, a hybrid cloud environment is a good option. By combining the two models, a hybrid cloud model provides a more tailored IT solution that meets specific business requirements.
- **Pros of a hybrid cloud:**
 - Highly flexible and scalable.
 - Cost effective.
 - Enhanced security.
- **Cons of a hybrid cloud:**
 - Communication in network level may be conflicted as it's used in both private and public clouds.

Table 1.1: Difference between public cloud and private cloud

Parameters	Public Cloud	Private Cloud
Infrastructure	Single-Tenant: Dedicated hardware and network for your business managed by an in-house technical team.	Multi-Tenant: Shared network hosted off site and managed by your service provider.
Business requirement	High performance, security, and customization and control options.	Affordable solutions that provide room for growth.
Best use	Protect your most sensitive data and applications.	Disaster recovery and application testing for smaller, public facing companies.
Scalability	Can be managed in-house. Extreme performance fine-grained control for both storage and compute.	Depends on the Service Level Agreement but usually easy via a self-managed tool the customer will use.
Support and maintenance	Your technical administrators.	Cloud Service Provider's technical team.
Cost	Large upfront cost to implement the hardware, software and staff resources. Maintenance and growth must also be built into ongoing costs (Capital expenditures).	Affordable option offering a pay-as-you-go service fee. Operating Cost – Pay as you go, scale up, scale down as needed, charged by the minute.
Security	Isolated network environment. Enhanced security to meet data protection legislation.	Basic security compliance. Some may offer bolt-on security options.
Performance	High performance from dedicated server.	Competing users can reduce performance levels.

1.3 LAYERS OF CLOUD

- Cloud computing is based on service models. These are categorized into four basic service models which are:
 - Infrastructure-as-a-Service (IaaS)
 - Platform-as-a-Service (PaaS)
 - Software-as-a-Service (SaaS)
 - BPO (Business Process Outsourcing)

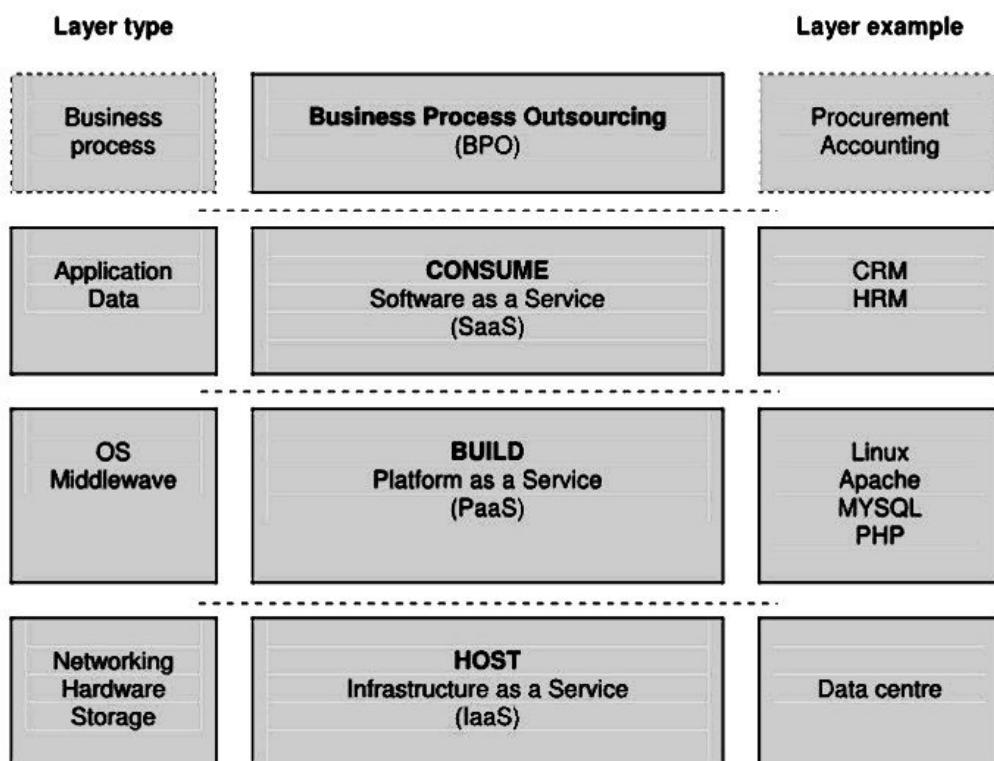


Fig. 1.4: Layers of Cloud Services

1. Infrastructure-as-a-Service (IaaS)

- IaaS is also known as **Hardware as a Service (Haas)**. It is one of the cloud computing platform's tiers. Customers can outsource their IT infrastructures such as servers, networking, processing, storage, virtual machines, and other resources to the company. Customers utilize a pay-per-use approach to access these resources through the Internet.

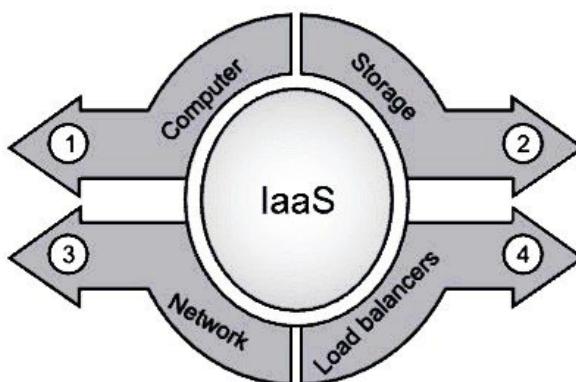


Fig. 1.5: Infrastructure as a Service

- IaaS provider provides the following services:
 1. **Compute:** Virtual central processor units and virtual main memory for the VMs that are supplied to end-users are included in Computing as a Service.
 2. **Storage:** IaaS provider provides back-end storage for storing files.
 3. **Network:** Network as a Service (NaaS) provides networking components such as routers, switches, and bridges for the VMs.
 4. **Load balancers:** It provides load balancing capability at the infrastructure layer.
- The lower end of managed cloud computing services where hardware resources are provided by an external provider and managed for you. IaaS provides users access to computing resources such as networking, processing power and data storage capacity.
- IaaS helps users to use computing power or virtual machines without labor intensive hardware investments or server management. Physically, the hardware resources are pulled from a variety of networks and servers distributed across different data centers; all of which are managed and maintained by the cloud service provider.
- For example, say a user wants a Linux system, with IaaS he/she will get access to it without having to worry about the networking of the machine on which Linux is installed or the physical system.
- IaaS is beneficial for customers who want to create cost-effective and highly scalable IT solutions where the expenses and complexities involved in managing hardware resources are outsourced to a service provider. Most of the IaaS packages include servers, networking, storage, and virtualization components while the users are responsible for installing and maintaining databases, OS, applications, and security components.
- Example of IaaS: Amazon EC2, Windows Azure, Rackspace, Google Compute Engine.

Features of IaaS Services:

- **Time Optimization:** A typical infrastructure as a service offering saves both time and money as the underlying hardware set up and support is provided by the service provider.
- **Resource Availability:** Resources are available on demand as and when required so there is no wastage of any unused resources and no delays on adding any resources.
- **Utility-based pricing model:** Pay only for the resources you actually use.

Advantages/Benefits of IaaS Services:

- **Shared infrastructure:** IaaS allows multiple users to share the same physical infrastructure.

- **Web access to the resources:** IaaS allows IT users to access resources over the internet.
- **Pay-as-per-use model:** IaaS providers provide services based on the pay-as-per-use basis. The users are required to pay for what they have used.
- **Focus on the core business:** IaaS providers focus on the organization's core business rather than on IT infrastructure.
- **On-demand scalability:** One of the most significant advantages of IaaS is on-demand scalability. Users that utilize IaaS don't have to worry about updating software or troubleshooting difficulties with physical components.

Disadvantages of IaaS Services:

- **Security:** One of the most pressing concerns in IaaS is security. The majority of IaaS suppliers are unable to guarantee complete security.
- **Maintenance & Upgrade:** Although IaaS service providers update the software, some companies do not receive upgrades.
- **Interoperability issues:** As it is difficult to transfer VMs from one IaaS provider to another, consumers may suffer vendor lock-in issues.

2. Platform-as-a-Service (PaaS)

- This cloud computing service is an advanced version of IaaS. Apart from just providing the IT infrastructure, PaaS also provides the computing platform and solution stack as a service.
- PaaS is a cloud computing service that provides developers with a framework that can be used for building custom applications online without having to worry about data storage, data serving, and management.
- A typical Platform-as-a-Service contributing in: Hosting Solutions, OS, Software tools for design and development, Environment for server-side scripting, DBMS, Network Access, Storage, Server Software, Support.
- Examples of PaaS solutions includes: Microsoft Azure, AWS Elastic Beanstalk, Force.com by Salesforce, Google App Engine, Rackspace Cloud Sites, OpenShift, and Apache Stratos.

Features of PaaS services:

- **Web-based user interfaces:** A web user interface or web app allows the user to interact with content or software running on a remote server through a web browser. The content or web page is downloaded from the web server and the user can interact with this content in a web browser which acts as a client.
- **Cloud-based computing model:** It allows development teams to build, test, deploy, manage, update, and scale applications faster and more cost-effectively.

- **Multi-tenant architecture:** It serves multiple customers using a single instance of software running on a server. Separate customers in a multi-tenant environment tap into the same data storage and hardware, each creating a dedicated instance.
- **Scalability, load balancing and failover:** High availability to eliminate single points of failure. If one server goes down, the website should not go offline. Scalability and acceptable performance under peak load. Typically, this also requires redundancy, so the load can be balanced across servers.

Advantages / Benefits of PaaS services:

- **Cost Effective:** No need to purchase hardware or pay expenses during downtime.
- **Time Savings:** No need to spend time setting up/maintaining the core stack.
- **Speed to Market:** Speed up the creation of applications.
- **Future-Proof:** Access to state-of-the-art data centre, hardware, and operating systems.

Disadvantages of PaaS services:

- With a PaaS, data security needs to be considered and scrutinised, as information is stored off-site.
- Not every part of your company's existing infrastructure may be built for the cloud.
- Finally, a less than ideal PaaS provider could leave your company feeling frustrated.

3. Software as a Service (SaaS)

- A special cloud computing service that incorporates both IaaS and PaaS service offerings. SaaS is a cloud computing service that provides application-level services tailored to diverse business needs such as business analytics, CRM, or marketing automation. SaaS is a cloud computing service offering that provides web-based software applications to customer's on-demand. SaaS providers host a fully-functional application through a browser-based interface and make it accessible to the users through the Internet.
- SaaS offerings allow the cloud to be leveraged for software architecture thereby reducing the overhead of support, maintenance, and operations as the applications run on systems belonging to the vendor. SaaS is the most familiar cloud computing service offering as users most often interact directly with SaaS applications like Netflix, Gmail, JIRA, Dropbox, or Salesforce.
- SaaS is a subscription-based offering where users subscribe to software on a monthly basis instead of purchasing it so there are no upfront costs involved. It also provides a provision to the users to end the subscription when it is no longer needed.

- Examples of SaaS solutions includes: SAP Business ByDesign, Zoho CRM, AppDynamics, Microsoft Office 365, Pardot Marketing Automation.

Features of SaaS Services:

- **Multi-tenancy cloud architecture:** Multi-tenancy is a kind of software architecture in which a single deployment of a software application serves multiple customers. Each customer is called a tenant. Tenants may be given the ability to customize some parts of the application, now a days applications are designed in a such a way that per tenant, the storage area is segregated by having different database altogether or having a different schemas inside a single database or same database with discriminators.
- **Familiar web-based interfaces:** Building on the consumer web that users already know. This can help you boost adoption and take-up rates.
- **Accelerated feature delivery:** With updates often rolled out weekly or monthly and no need to maintain or support legacy versions of the software.
- **Open integration protocols and APIs:** Enabling the event of 'mash-ups' which combine data, presentation and functionality from multiple services.
- **Collaborative and social functions:** Which allow people in several teams and or locations work co-operatively with each other.

Advantages/Benefits of SaaS Services:

- **Low setup and infrastructure costs:** You just buy what you would like with no cost that must be depreciated on your record over time.
- **Accessible from anywhere:** Just connect to the web and you can work from wherever you need to be via desktop, laptop, tablet or mobile or other networked device. Via any networked device, making it easier to manage, access data and knowledge and keep data in sync.
- **Scalability:** You can adapt your requirements to the amount of individuals who got to use the system, the quantity of knowledge and therefore the functionality required as your business grows.
- **Automatic, frequent updates:** Providers offer timely improvements because of their scale and since they receive feedback about what their customers need. This frees up your IT department for other more business-critical tasks.
- **Security at the highest level required by any customer:** Because of the shared nature of the service, all users enjoy the safety level that's been found out for those with the very best need.

Disadvantages of SaaS services:

- **Insufficient Data Security:** This is one of the top concerns for companies who are looking to opt for a SaaS-based application model.

- Difficulty with Regulations Compliance.
- Cumbersome Data Mobility.
- Low Performance.
- Troublesome Software Integration.

4. BPO (Business Process Outsourcing)

- BPO is an abbreviation that stands for Business Process Outsourcing. It consists of front office customer services such as tech support and back office business functions like billing. When a company has a big workload, and they want their non-core work to be done by an expert at low costs, then they easily outsource their work to another country that has a large work force at a lower cost. This process is called Business Process Outsourcing.
- In a BPO, the entire business is handled by a third party. An external service provider transfers the project to a third party on a contract basis. The third-party has the responsibility to improve the service provider's customer experience and provide excellent customer service.

Table 1.2: Difference between IaaS, PaaS, and SaaS

IaaS	PaaS	SaaS
It provides a virtual data center to store information and create platforms for app development, testing, and deployment.	It provides virtual platforms and tools to create, test, and deploy apps.	It provides web software and apps to complete business tasks.
It provides access to resources such as virtual machines, virtual storage, etc.	It provides runtime environments and deployment tools for applications.	It provides software as a service to the end users.
It is used by network architects.	It is used by developers.	It is used by end users.
IaaS provides only Infrastructure.	PaaS provides Infrastructure + Platform.	SaaS provides Infrastructure + Platform + Software.

1.4 DESIRED FEATURES OF A CLOUD

- **SELF-SERVICE:** It's one of the most important and crucial aspects of cloud computing. Customers expect on-demand service from cloud computing by instant assessing resources. To support this cloud, allow self-service access so that customer can request, pay and use services without intervention of human operators. This is a key

feature of Cloud, and a customer may also regulate the computing resources according to his requirements.

- **Per-usages metering and Billing:** Billing is the process where the cloud computing service subscribers are charged based on the metered data. Billing usually happens monthly. Billing uses pricing rates defined against usage plans and computes the invoice against the usage data.
- **Elasticity:** Elastic computing is the ability to quickly expand or decrease computer processing, memory, and storage resources to meet changing demands without worrying about capacity planning and engineering for peak usage.
- **Customization:** Cloud computing changes the customization equation. With cloud-based ERP, companies can develop new functionality in a matter of weeks instead of months or years and carry over all customizations seamlessly to the latest release of the application.

1.5 BENEFITS OF CLOUD COMPUTING

- **Easy implementation:** Cloud hosting enables businesses to keep the same apps and business processes without having to deal with backend technological issues. A cloud infrastructure is managed over the Internet and can be used by businesses fast and easily.
- **Accessibility:** You may access your data from anywhere at any time. By guaranteeing that your application is always available, an Internet cloud architecture boosts corporate productivity and efficiency. This makes it simple for users in different places to collaborate and share information.
- **No hardware required:** A physical storage centre is no longer required because everything will be hosted in the cloud. Creating and optimizing the cloud cost structure policy can reduce the cost of cloud storage significantly while maintaining the company's business goals related to data storage in the cloud.
- **Cost per head:** Cloud hosting services keep overhead technological expenditures to a minimum, allowing businesses to use more time and resources to upgrade their infrastructure.
- **Flexibility for growth:** Because the cloud is easily scalable, businesses may add or withdraw resources as needed. As businesses expand, their systems will expand as well.
- **Efficient recovery:** Cloud computing allows users to get applications and data more quickly and accurately. It is the most efficient recovery method since it requires minimal downtime.
- **Data Security:** Data security is one of the biggest advantages of cloud computing. Cloud offers many advanced features related to security and ensures that data is securely stored and handled.

1.6 DISADVANTAGES OF CLOUD COMPUTING

- **No longer in control:** You're handing over your data and information when you move services to the cloud. Companies with in-house IT professionals will be unable to resolve problems on their own. Stratosphere Networks provides a live help desk that is available 24 hours a day, 7 days a week to resolve any issues.
- **May not get all the features:** All cloud services are not created equal. Some cloud providers provide restricted versions that simply allow the most popular features, so you may not get all of the functionality or customizations you desire. Make sure you understand everything your cloud service provider has to offer before signing up.
- **Doesn't mean you should do away with servers:** Although you may have fewer servers to manage which means less work for your IT team, this does not imply you can eliminate all of your servers and employees. While having data centers and a cloud architecture may appear to be pricey, redundancy is critical for backup and recovery.
- **No Redundancy:** A cloud server is neither redundant nor backed up in any way. Avoid being burnt by obtaining a redundancy plan, as technology can fail at any time. Although it is an additional cost, it is usually well worth it.
- **Bandwidth issues:** Clients must prepare ahead of time for optimal performance and avoid cramming huge numbers of servers and storage devices into a small number of data centers.

1.7 CLOUD INFRASTRUCTURE MANAGEMENT

1.7.1 Cloud Infrastructure

- **Cloud infrastructure** consists of all of the hardware and software elements needed for cloud computing, including Compute (server), Networking, Storage, Virtualization resources.
- A User Interface (UI) for controlling these virtual resources is generally included with cloud infrastructure types.
- IaaS or Infrastructure as a Service is a well-known and widely used example of this concept. IaaS allows a team or company to get the computer infrastructure they need over the Internet, including computing power (whether on actual or virtual machines, as is more probable), storage, and a variety of other services like load balancers and firewalls. Instead of supplying and managing their own physical infrastructure, they do this. Instead, they use the IaaS provider to lease the resources they require.
- Cloud infrastructure means the hardware and software components.
- These components are server, storage, networking and virtualization software.
- These components are required to support the computing requirements of a cloud computing model.

1.7.2 Components of Cloud Infrastructure

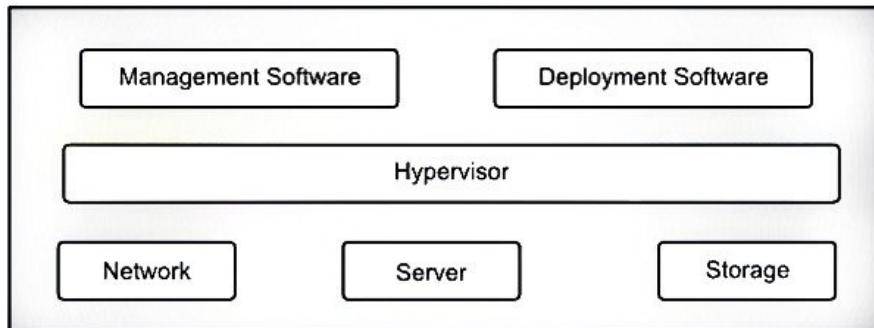


Fig. 1.6: Cloud Infrastructural Components

- **Following are the Components of Cloud Infrastructure:**
- 1. **Hypervisor:** Hypervisor is a firmware or low-level program. It acts as a Virtual Machine Manager. It enables to share a physical instance of cloud resources between several customers.
- 2. **Management Software:** Management software assists to maintain and configure the infrastructure.
- 3. **Deployment Software:** Deployment software assists to deploy and integrate the application on the cloud.
- 4. **Network:** Network is the key component of the cloud infrastructure. It enables to connect cloud services over the Internet. The customer can customize the network route and protocol i.e. possible to deliver network as a utility over the Internet.
- 5. **Server:** The server assists to compute the resource sharing and offers other services like resource allocation and deallocation, monitoring the resources, provides the security etc.
- 6. **Storage:** Cloud keeps many copies of storage. Using these copies of resources, it extracts another resource if any one of the resources fails.

1.7.3 Infrastructural Constraints

- **Following are the basic constraints:**
- 1. Transparency
- 2. Scalability
- 3. Intelligent Monitoring
- 4. Security

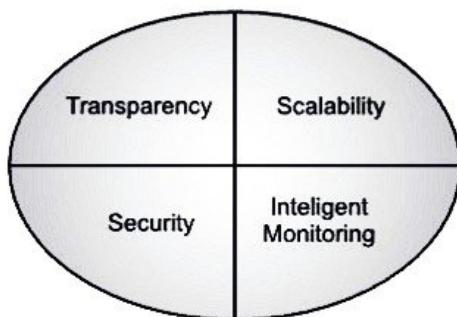


Fig. 1.7: Infrastructure of Cloud Computing

1. Transparency:

- In a Cloud environment, virtualization is the key to share the resources.
- It is impossible to satisfy the demand with single resource or server. Hence, there should be transparency in resources, load balancing and application, so that we can scale the resources on demand.

2. Scalability:

- Scaling up an application is easy but scaling up an application delivery solution is not easy because it includes configuration overhead or even rearchitecting the network.
- Hence, application delivery is required to be scalable that need the virtual infrastructure so that, resources are provisioned and de-provisioned easily.

3. Intelligent Monitoring:

- Application solution delivery is required to be capable of intelligent monitoring to achieve transparency and scalability.

4. Security:

- In security, the mega data center in the cloud must be securely architected.
- The control node, an entry point in mega data center also requires to be secure.

1.7.4 Cloud Infrastructure Management

- Cloud infrastructure management contains the procedures and tools required to efficiently allocate and distribute critical resources when and where they are needed. An excellent example of such a tool is the UI or dashboard which serves as a control panel for deploying, configuring, and administering cloud infrastructure. Cloud infrastructure management is beneficial for providing cloud services to both:
 1. Internal users who utilize cloud resources, such as developers or other jobs.
 2. Customers and business partners are examples of external users.
- The fundamental goal of cloud infrastructure management is to enable business scalability while unifying IT resources and allowing multiple users to utilise the same infrastructure without jeopardising their data.

- This decreases operational expenses in the long term.
- A Cloud Infrastructure Management Interface (CIMI) is an open standard API for managing cloud infrastructure that allows users to manage it more easily while maintaining consistent communication across cloud ecosystems. This allows cloud suppliers, developers, and customers to handle their data in an accessible manner.

What does cloud infrastructure management do:

- It is the technique aided by technological tools that ensures proper cloud usage supervision.
- Businesses may use it to build, configure, grow, and retire cloud infrastructure as required.
- For cloud settings, cloud infrastructure management functions similarly to a command centre or central nervous system. By offering the tools needed to securely manage consolidated resources, cloud infrastructure management provides for increased operational flexibility and agility while retaining cost savings.
- The ability to achieve and sustain the promise of multi-cloud and hybrid cloud solutions is ultimately determined by cloud infrastructure management. These dispersed infrastructure architectures without it generates operational complexity that is difficult for individuals to handle manually. Even small teams can offer web-scale services with the right cloud infrastructure management.

1.7.5 Cloud Infrastructure Management Tools

- Provide engineers and other IT pros the tools they need to run their cloud environments on a daily basis.
- While cloud providers frequently provide native management tools, these typically only allow control over their platform and services. Third-party cloud management solutions generally claim to provide a "360-degree view" and management capabilities across all environments, which may be required in multi-cloud and hybrid cloud settings.
- Cloud infrastructure management solutions provide some combinations of the following functionalities in either situation:
 1. **Provisioning and Configuration:** These tools are used by developers, systems engineers, and other IT professionals to set up and configure the hardware and software resources they require:
 - Setting up a new server.
 - Installing an operating system or other applications.
 - Allocating storage resources and other cloud infrastructure requirements.
 - This contains capabilities for allowing and managing self-service provisioning in which end users utilize a dashboard or other methods to create their own resources as needed according to preset rules.

2. **Visibility and Monitoring:** Operators can use cloud infrastructure management technologies to "see" their environments. They also contain or connect with monitoring technologies that:
 - o check system health.
 - o provide real-time warnings and notifications.
 - o generate reporting and analytics.
3. **Resource allocation:** Resource allocation capabilities, which are related to cost optimization, provide consumers granular control over how they utilize cloud infrastructure, including self-service provisioning. This is related to budgeting in that it involves properly allocating pooled resources and, in certain circumstances, establishing conditions for going over budget.
Resource allocation capabilities, which are related to cost optimization, provide consumers granular control over how they utilize cloud infrastructure, including self-service provisioning. This is related to budgeting in that it involves properly allocating pooled resources and, in certain circumstances, establishing conditions for going over budget.
4. **Cost optimization:** Cloud infrastructure management solutions must have the capacity to manage expenses. Without this component, businesses are more likely to experience "sticker shock" when their cloud bill arrives. The key to improving the ROI of cloud infrastructure is proactive cost management through methods such as shutting off unused or unneeded resources.
5. **Automation:** Automation features for different operational activities such as configuration management, auto-provisioning, and auto-scaling are occasionally available in cloud infrastructure management solutions.
6. **Security:** Another component of a comprehensive cloud security plan is cloud infrastructure management tools. They're one way to appropriately configure a cloud provider's native security measures depending on a specific arrangement and set of requirements.

1.8 INFRASTRUCTURE-AS-A-SERVICE

This point already cover in same unit check point 1.3.

Summary

- The "cloud" refers to servers that are accessed over the Internet and the software and databases that run on those servers.
- Cloud computing transforms IT infrastructure into a utility: It lets you 'plug into' infrastructure via the internet and use computing resources without installing and maintaining them on-premises.

- Examples of cloud computing includes: Google Docs, Microsoft Office 365, Email, Calendar, Skype, WhatsApp, Zoom, AWS Lambda etc.
- The public cloud makes systems and services public to anybody with an internet connection. Because of its openness, the public cloud may be less secure.
- Public clouds are ideal for small and medium sized businesses with a tight budget requiring a quick and easy platform in which to deploy IT resources.
- Within a company, the private cloud allows systems and services to be accessed. Because of its private character, it is more secure.
- A collection of organizations can use the community cloud to access systems and services.
- The hybrid cloud is a combination of public and private cloud, with important tasks being handled by private cloud and non-critical tasks handled by public cloud.
- 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), BPO (Business Process Outsourcing).
- IaaS helps users to use computing power or virtual machines without labor-intensive hardware investments or server management. Example of IaaS: Amazon EC2, Windows Azure, Rackspace, Google Compute Engine.
- PaaS is a cloud computing service that provides developers with a framework that can be used for building custom applications. Examples of PaaS solutions include Microsoft Azure, AWS Elastic Beanstalk, Force.com by Salesforce, Google App Engine, Rackspace Cloud Sites, OpenShift, and Apache Stratos.
- In Multi-tenancy cloud architecture all users and applications share a standard infrastructure that's centrally maintained. In terms of security, for instance this suggests that each user gets the very best level of security laid out in your package.
- BPO is an abbreviation that stands for Business Process Outsourcing. It consists of front-office customer services such as tech support and back-office business functions like billing.

Check Your Understanding

1. What type of computing technology refers to services and applications that typically run on a distributed network through virtualized resources?

(a) Distributed Computing	(b) Cloud Computing
(c) Soft Computing	(d) Parallel Computing
2. Which one of the following options can be considered as the Cloud?

(a) Hadoop	(b) Intranet
(c) Web Applications	(d) All of the mentioned

3. Cloud computing is a kind of abstraction which is based on the notion of combining physical resources and represents them as _____ resources to users.
 (a) Real (b) Cloud
 (c) Virtual (d) None of the mentioned
4. Which one of the following cloud concepts is related to sharing and pooling the resources?
 (a) Polymorphism (b) Virtualization
 (c) Abstraction (d) None of the mentioned
5. Which one of the following is Cloud Platform by Amazon?
 (a) Azure (b) AWS
 (c) Cloudera (d) All of the mentioned
6. Which of the following is the correct full form of SaaS?
 (a) Storage-as-a-Service (b) Server-as-a-Software
 (c) Software-as-a-Service (d) None of the above
7. Which one of the following can be considered as the benefit of PaaS?
 (a) Lower administrative overhead (b) Lower total cost of ownership
 (c) More current system software (d) All of the above
8. The terms "IaaS" stand for?
 (a) IT-as-a-Service (b) Infrastructure-as-a-Service
 (c) Internet-as-a-Service (d) Interoperability-as-a-Service
9. IaaS usually shares issues with the _____.
 (a) PaaS (b) SaaS
 (c) Both a and b (d) None of the above
10. Which of the following can be referred to the location and management of the cloud's infrastructure?
 (a) Service (b) Deployment
 (c) Application (d) None of the mentioned

Answers

1. (b)	2. (a)	3. (c)	4. (b)	5. (c)	6. (c)	7. (d)	8. (b)	9. (c)	10. (b)
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Practice Questions

Q.I Answer the following questions in short.

1. What is cloud computing?
2. Which platforms are used for large scale cloud computing?
3. What do you mean by software as a service?
4. What is on-demand functionality? How is it provided in cloud computing?

5. What is public cloud?
6. What are the security benefits of cloud computing?
7. What is the difference between cloud and traditional datacenters?
8. Which services are provided by Window azure operating system?
9. What do you mean by VPN? What does it contain?
10. What are the advantages of Cloud Computing?
11. What cloud technologies have you worked with?
12. What are the types of services in cloud computing?
13. What are the disadvantages of SaaS?
14. What is storage in cloud?

Q.II Answer the following questions.

1. What are the advantages of using cloud computing?
2. What is the difference in cloud computing and computing for mobiles?
3. What are the security aspects provided with cloud?
4. List out different layers which define cloud architecture?
5. Explain what is the use of "EUCALYPTUS" in cloud computing?
6. What is the requirement of virtualization platform in implementing cloud?
7. Before going for cloud computing platform what are the essential things to be taken in concern by users?
8. What are the security laws which are implemented to secure data in a cloud ?
9. How important is the platform as a service?
10. What is a cloud service?
11. What are the features cloud computing?
12. What are the advantages and disadvantages of IaaS?
13. What is cloud Infrastructure Management?
14. Explain the difference between PaaS and SaaS?
15. What is the difference between public cloud and private cloud?
16. What are the different layers of Cloud Computing?
17. What are the different types of cloud computing?
18. What are the features of PaaS?

Q.III Define the terms.

1. Cloud Computing
2. Public Cloud
3. PaaS Platform as a service
4. Infrastructure Management
5. Data Security



2...

Abstraction and Virtualization

Learning Objectives ...

- To understand virtualization technology.
- To learn about Load Balancing and Virtualization - The Google Cloud.
- To understand Hypervisors - Virtual Machine Types.
- To know about salesforce.com, force.com, Amazon EC2.

2.1 USING VIRTUALIZATION TECHNOLOGY

- Virtualization is the "creation of a virtual version of something, sort of a server, a desktop, a storage device and OS or network resources".
- In other words, virtualization could also be a way, to share one physical instance of a resource or an application among multiple customers and organizations. It does so by assigning a logical name to a physical storage and providing a pointer to physical resources when demanded.
- Creation of a virtual machine over existing OS and hardware is understood as Hardware Virtualization. A virtual machine provides an environment that's logically separated from the underlying hardware.
- The machine on which the virtual machine is going to create is known as Host Machine and that virtual machine is referred as a Guest Machine.
- The virtualization process follows the steps listed below:
 1. Hypervisors detach the physical resources from their physical environments.
 2. Resources are taken and divided, as needed, from the physical environment to the varied virtual environments.
 3. System users work with and perform computations within the virtual environment.
 4. Once the virtual environment is running, a user or program can send an instruction that needs extra resources from the physical environment. In

(2.1)

response, the hypervisor relays the message to the physical system and stores the changes. This process will happen at an almost native speed.

- The virtual environment is usually mentioned as a Guest Machine or Virtual Machine. The VM acts sort of a single file which will be transferred from one computer to a different and opened in both; it is expected to perform in an equivalent way on every computer.

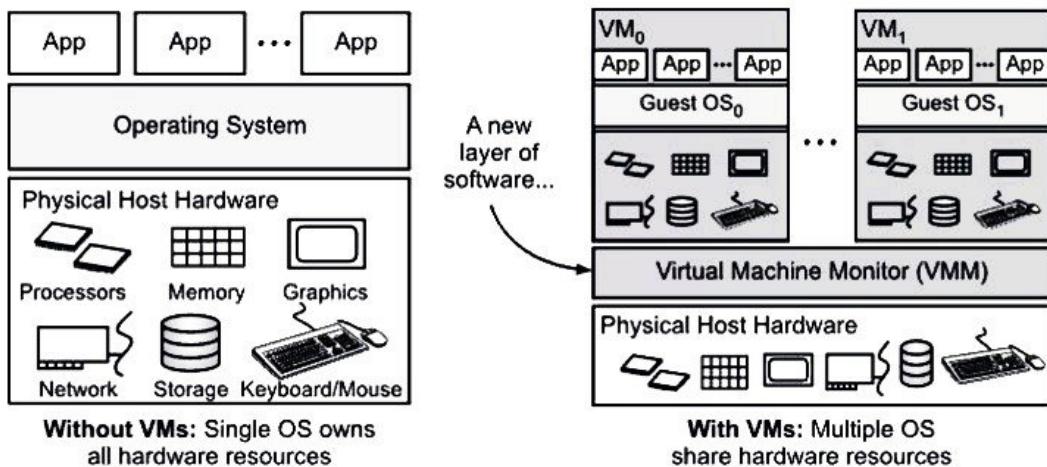


Fig. 2.1: Abstraction and Virtualization

2.1.1 Types of Virtualization

- There are six areas of IT where virtualization is making headway:
 - Network virtualization** could also be a way of blending the available resources during a network by splitting up the available bandwidth into channels, each of which is independent from the others and can be assigned or reassigned to a specific server or device in real time. The idea is that virtualization covers the true complexity of the network by separating it into manageable parts, very similar to how your partitioned disk drive makes it easier to manage your files.
 - Storage virtualization** is the pooling of physical storage from multiple network memory devices into one storage device that's managed from a central console. Storage virtualization is usually utilized in cargo area networks.
 - Server virtualization** is a technology for partitioning one physical server into multiple virtual servers. Each of these virtual servers can run its own operating system and applications, and perform as if it is an individual server.
 - Data virtualization** is abstracting the normal technical details of knowledge and data management like location, performance or format, in favor of broader access and more resiliencies tied to business needs.
 - Desktop virtualization** is virtualizing a workstation load instead of a server. This allows the user to access the desktop remotely, typically employing a thin client at

the desk. Since the workstation is actually running during a data center server, access thereto are often both safer and portable. The OS license does still have to be accounted for also because of the infrastructure.

- (vi) **Application virtualization** is abstracting the appliance layer far away from the OS. This way, the appliance can run in an encapsulated form without being depended upon by the OS underneath. This can allows a windows application to run on Linux and therefore the other way around, additionally to adding a level of isolation.
- Virtualization are often viewed as a neighborhood of an overall trend in enterprise IT that has autonomic computing, a scenario during which the IT environment are getting to be ready to manage itself supported perceived activity, and utility computing, during which pc processing power is seen as a utility that clients pays for fewer than as needed. The usual goal of virtualization is to centralize administrative tasks while improving scalability and workloads.

2.1.2 Advantages of Virtualization

- Lower costs:** Virtualization reduces the quantity of hardware servers necessary within a corporation and data center. This lowers the general cost of shopping for and maintaining large amounts of hardware.
- Easier disaster recovery:** Disaster recovery is extremely simple during a virtualized environment. Regular snapshots provide up-to-date data, allowing virtual machines to be feasibly protected and recovered. Even in an emergency, a virtual machine are often migrated to a replacement location within minutes.
- Easier testing:** Testing is a smaller amount complicated during a virtual environment. Even if an outsized mistake is formed, the test does not stop and return to the start. It can simply return to the previous snapshot and proceed with the test.
- Quicker backups:** Backups are often taken of both the virtual server and therefore the virtual machine. Automatic snapshots are taken throughout the day to ensure that each one data is up so far. Furthermore, the virtual machines are often easily migrated between one another and efficiently redeployed.
- Improved productivity:** Fewer physical resources end in less time spent managing and maintaining the servers. Tasks which will take days or weeks during a physical environment are often wiped out minutes. This allows staff members to spend the bulk of their time on more productive tasks, like raising revenue and fostering business initiatives.

2.1.3 Limitations of Virtualization

- Before converting to a virtualized environment, it's important to think about the varied upfront costs. The necessary investments in virtualization software, also as

hardware which may be required to make the virtualization possible, are often costly. If the fundamental infrastructure is quite five years old, then initial renewal budget will need to be considered. Fortunately, many businesses have the capacity to accommodate virtualization without spending large amounts of money. Also, the prices are often offset by collaborating with a managed service provider that gives monthly leasing or purchase options.

- There also are software licensing considerations that have got to be taken under consideration when creating a virtualized environment. Companies must make sure that they need a transparent understanding of how their vendors view software use within a virtualized environment. This is becoming less of a limitation as more software providers adapt to the increased use of virtualization.
- Converting to virtualization takes time and should accompany a learning curve. Implementing and controlling a virtualized environment demands each IT staffer to be trained and possess expertise in virtualization. Furthermore, some applications don't adapt well when brought into a virtual environment. The IT staff will prepared to face these challenges and will address them before converting.
- There are also security risks involved with virtualization. Data is crucial to the success of a business and, therefore, may be a common target for attacks. The chances of experiencing a knowledge breach significantly increase while using virtualization.
- Finally, during a virtual environment, users lose control of what they will do because there are several links that have got to collaborate to perform an equivalent task. If any part is not working, then the entire operation will fail.

2.2 LOAD BALANCING AND VIRTUALIZATION – THE GOOGLE CLOUD

- Load balancing is the process of distributing traffic across your network of servers to make sure that the system doesn't get overwhelmed, and every one requests are handled easily and efficiently.

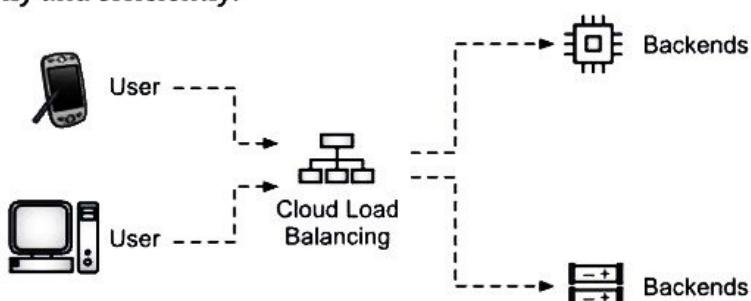


Fig. 2.2: Simple Overview of Load Balancing

- Modern high traffic websites serve many thousands, if not millions, of concurrent requests from users or clients and return the right text, images, video, or application

data, all in a fast and reliable manner. You've probably all experienced visiting your favorite website, only to get long wait times, connection timeout errors, or images and videos buffering. And a lot of the times, this is because the website backend is unable to cost effectively scale to meet these high volumes.

- The logical answer here is to feature more backend servers to assist serve traffic. But the subsequent question becomes, how does one distribute traffic to those backend servers supporting capacity and health?
- This is where load balancing makes a splash. Load balancing is the process of distributing traffic across your network of servers to make sure that the system doesn't get overwhelmed, and every one requests are handled easily and efficiently.
- **Google Cloud Load Balancing** is a fully distributed, software-defined managed service. It provides scaling, high availability, and traffic management for internet-facing and private applications.

Google Cloud Load Balancing Options:

- To decide which load balancer best suits your implementation, you need to think about whether you need it.
 1. **Global or regional load balancing:** Global load balancing means backend endpoints live in multiple regions. Regional load balancing means backend endpoints live in a single region.
 2. **External or internal load balancing:** External load balancing supports Instance groups, Zonal Network Endpoint Groups (NEGs), Buckets in Cloud Storage, Serverless NEGs, and Internet NEGs. It can be used to support web application, and database tier services. Internal load balancing is a managed service that can only be accessed on an internal IP address and in the chosen region of your virtual private cloud network. At a high level, it consists of one or more backend services to which the load balancer forwards traffic and an internal IP address to which clients send traffic. It can be used to run the applications behind an internal IP address and disperse HTTP/HTTPS traffic to the backend application hosted either on Google Kubernetes Engine or Google Compute Engine. You can use it to route and balance load traffic to your virtual machines.

Why is load balancing important?

- There are variety of reasons why load balancing is vital. Load balancer lets you:
 - Distribute load balanced resources in single or multiple regions.
 - Meet your high availability requirements.
 - Scale your resources up or down with intelligent autoscaling.
 - Use cloud content delivery network (CDN) for optimal content delivery.

How to decide which load balancer to use?

- There are many load balancing options counting on where exactly they have a load balancer within the architecture.
- They would use external load balancers to distribute traffic coming from the web to their Google cloud network and internal load balancers to distribute traffic within their GCP network.

Google Cloud offers the following load balancing features:

- Single IP address to serve as the frontend.
- Automatic intelligent autoscaling of your backends.
- External load balancing for when your users reach your applications from the internet.
- Internal load balancing for when your clients are inside of Google Cloud.
- Regional load balancing for when your applications are available in a single region.
- Global load balancing for when your applications are available across the world.
- Layer 4 - based load balancing to direct traffic based on data from network and transport layer protocols such as TCP, UDP, ESP, or ICMP.
- Layer 7 - based load balancing to add request routing decisions based on attributes, such as the HTTP header and the uniform resource identifier.
- Integration with Cloud CDN for cached content delivery.

2.3 UNDERSTATING HYPERVISORS – VIRTUAL MACHINE TYPES

- A hypervisor, also referred to as a Virtual Machine Monitor or VMM, is software that makes and runs Virtual Machines (VMs). A hypervisor allows one host computer to support multiple guest VMs by virtually sharing its resources, like memory and processing.

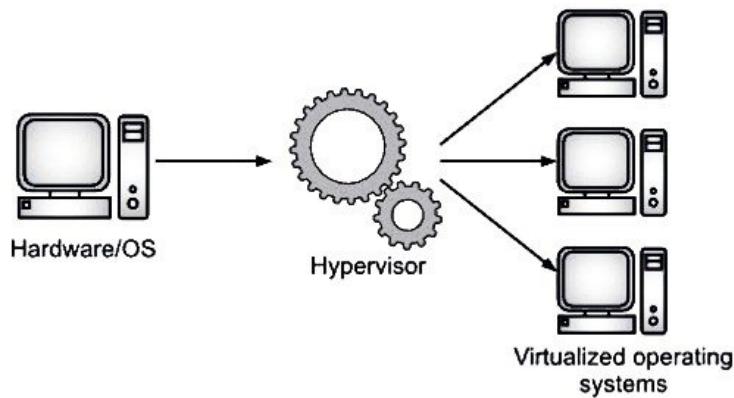


Fig. 2.3: Hypervisor

Why use a Hypervisor?

- Hypervisors make it possible to use more of a system's available resources and provide greater IT mobility since the guest VMs are independent of the host hardware. This means they will be easily moved between different servers. Because multiple virtual machines can escape from 1 physical server with a hypervisor, a hypervisor reduces space, energy and maintenance requirements.

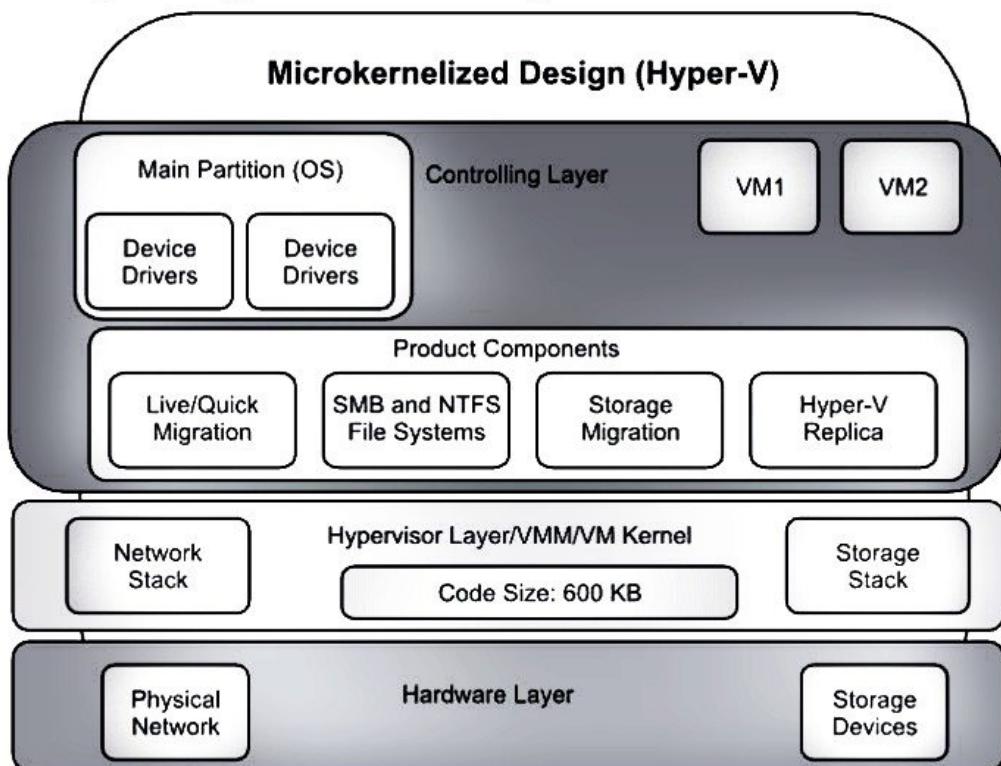


Fig. 2.4: The Microkernelized Hypervisor Design

- If you recognize what a personal cloud is and you recognize the infrastructure of it, you've probably heard about hypervisor.
- It is the neighborhood of the private cloud that manages the virtual machines, i.e. it is the part (program) that permits multiple operating systems to share an equivalent hardware. Each OS could use all the hardware (processor, memory) if no other OS is on. That is the utmost hardware available to at least one OS within the cloud.
- Nevertheless, the hypervisor is what controls and allocates what portion of hardware resources each operating system should get, in order everyone to get what they need and not to disrupt each other.
- Virtualization is changing the mindset from physical to logical.

- What virtualization means is creating more logical IT resources, called virtual systems, within one physical system. That's called system virtualization. It most ordinarily uses the hypervisor for managing the resources for each virtual system. The hypervisor may be software which will virtualize the hardware resources.

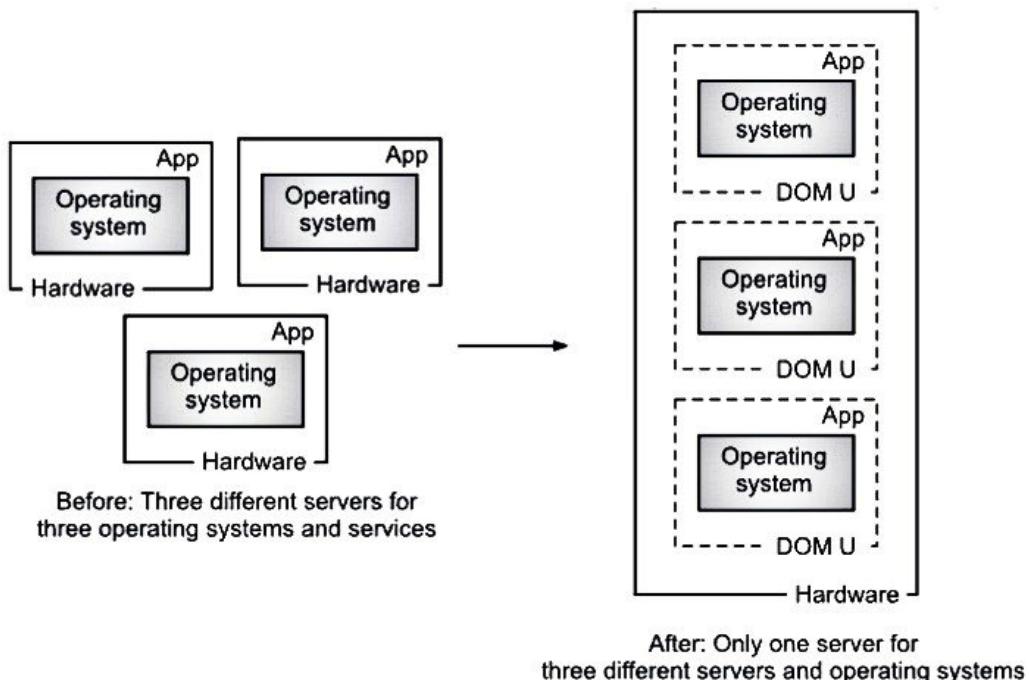


Fig. 2.5: (Hypervisor) software which will virtualize the hardware resources.

2.3.1 Types of Hypervisor

- There are two types of hypervisors:
 - Type 1 hypervisor:
 - Type 2 hypervisor:
- Type 1 hypervisor:**
- A type 1 hypervisor runs directly on the hardware, and the virtual machines and the management operating system (if there is one) sit on top of the hypervisor and access hardware through the hypervisor. A type 1 hypervisor enables the performance of guest operating systems in virtual machines to match that of running the same guest operating system directly on bare metal hardware. This matching of performance is achieved by allowing the virtual machines direct access to the processor's kernel mode, ring 0, in addition to other performance optimizations such as high performance virtual hard disks, low latency and high throughput net-working stacks, and efficient memory handling.

- **Example Type 1 hypervisor:**

- (i) **VMware ESX and ESXi:**

- These hypervisors offer advanced features and scalability, but require licensing, therefore the costs are higher.
 - There are some lower-cost bundles that VMware offers and that they can make hypervisor technology cheaper for little infrastructures.
 - VMware is that the leader within the Type-1 hypervisors. Their vSphere/ESXi product is out there during a free edition and 5 commercial editions.

- (ii) **Microsoft Hyper-V:**

- The Microsoft hypervisor, Hyper-V doesn't offer many of the advanced features that VMware's products provide.
 - However, with XenServer and vSphere, Hyper-V is one among the highest 3 Type-1 hypervisors.
 - It was first released with Windows Server, but now Hyper-V has been greatly enhanced with Windows Server 2012 Hyper-V. Hyper-V is out there in both a free edition (with no GUI and no virtualization rights) and 4 commercial editions – Foundations (OEM only), Essentials, Standard, and Datacenter. Hyper-V

- 2. **Type 2 hypervisor:**

- A type 2 hypervisor runs on top of an operating system that is installed on the physical hardware. This is commonly seen on desktop virtualization solutions such as Windows Virtual PC. Typically, these solutions are not very efficient because all operations have to run through the host operating system installed on the hardware, and virtual machines cannot directly access the processor's ring 0, which is where kernel mode instructions are executed. The advantage is that no special hardware is required.

- **Example Type 2 hypervisor:**

- (i) **VMware Workstation/Fusion/Player:**

- VMware Player is a free virtualization hypervisor.
 - It is intended to run just one virtual machine (VM) and doesn't allow creating VMs.
 - VMware Workstation could also be a more robust hypervisor with some advanced features, like record-and-replay and VM snapshot support.
 - VMware Workstation has three major use cases:
 - For running multiple different operating systems or versions of 1 OS on one desktop,
 - For developers that require sandbox environments and snapshots, or
 - For labs and demonstration purposes.

(ii) VMware Server:

- VMware Server may be a free, hosted virtualization hypervisor that's very almost like the VMware Workstation.
- VMware has halted development on Server since 2009

2.3.2 Virtual Machine Types

- A **Virtual Machine (VM)** is a compute resource that uses software instead of a physical computer to run programs and deploy apps. One or more virtual "guest" machines run on a physical "host" machine. Each virtual machine runs its own operating system and functions separately from the other VMs, even when they are all running on the same host. This means, a virtual MacOS virtual machine can run on a physical PC.
- The two types of Virtual Machines:
 1. **A process virtual machine** allows a single process to run as an application on a host machine, providing a platform-independent programming environment by masking the information of the underlying hardware or operating system. An example of a process VM is the Java Virtual Machine, which enables any operating system to run Java applications as if they were native to that system.
 2. **A system virtual machine** is fully virtualized to substitute for a physical machine. A system platform supports the sharing of a host computer's physical resources between multiple virtual machines, each running its own copy of the operating system. This virtualization process relies on a hypervisor, which can run on bare hardware, such as VMware ESXi, or on top of an operating system.

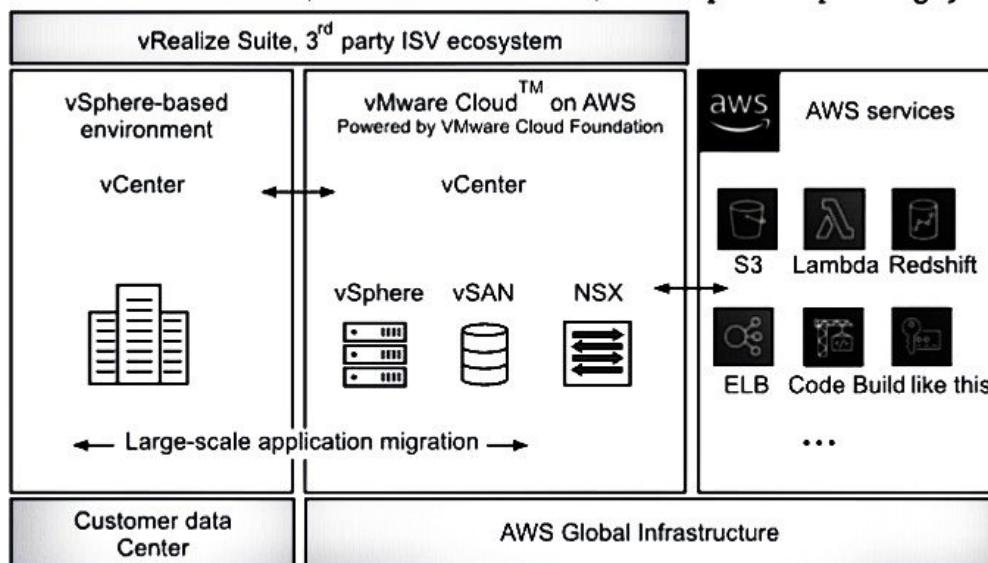


Fig. 2.6: Virtual Machine Cloud on AWS

2.4 EXPLORING SAAS – SALESFORCE.COM

2.4.1 SaaS

- Software-as-a-Service or SaaS may be a way of delivering applications over the web – as a service. Also referred to as cloud software, ASP, on-demand software or hosted software. The first applications for consumers were things like webmail, bookmarking and photo sharing. In business, things like recruitment, expenses and customer relationship management were among the first innovations. SaaS has since become a widely used business model with more and more different sorts of applications available via the cloud.
- Cloud computing allows companies to consume computing resources as a utility within the same way they are doing electricity or water. Recent developments have helped make this a far better option for several businesses than fixing and running their computing infrastructure in-house.
- The growth of SaaS has been fuelled by:
 1. **The growing use of mobile devices:** Where people want to be ready to connect from anywhere, not just the office. Web-based solutions work well to satisfy this need.
 2. **Increasing broadband access:** This made standard internet connectivity speeds adequate for using SaaS applications. More widespread broadband connectivity also made it easier for users to go online to services in several locations.
 3. **The standardisation of digital technologies:** Common protocols make it easier to share, integrate and scale cloud-based programs and services also as providing better user experiences during a multi-device environment.
 4. **Growing popularity and usage of web-like interfaces:** More and more users are happy to figure this way because of the familiarity, usability and ease of web-like environments.

2.4.2 Salesforce.com

- Salesforce.com, Inc. is an American cloud-based software company headquartered in San Francisco, California.
- Salesforce.com is a well-known Customer Relationship Management (CRM) application used for financial, delivery and staffing related to business system operations.
- A CRM application consists of a set of workflows together with software that helps manage customer related activities and information. These activities are related to sales (such as using customer information to generate future leads), marketing tasks (like using historical sales data to develop sales strategies), or providing better customer service (by using call center data).

- Salesforce itself may be a cloud computing software-as-a-service (SaaS) company that has been in business since 1999. It started as a cloud-based CRM software company years before SaaS became ubiquitous throughout enterprises. Over 150,000 companies run Salesforce in some form.
- Salesforce has a collection of applications and integrations, and uses APIs to connect with other applications like SAP or Oracle to access data or extend the capabilities in those systems. The APIs can read and write data to these systems to ensure you're always accessing the most up-to-date information.
- Salesforce customer relationship management (CRM) service comprises several broad categories: Sales Cloud, Service Cloud, Marketing Cloud, Commerce Cloud, Analytics Cloud, Community Cloud.
- Here, are prime reasons for using Salesforce CRM:
 - It is complete feature-rich solution for marketing, sales, service, partner management, and community management.
 - Salesforce data is stored in the cloud so your team can use it from anywhere in the world with the help of an Internet connection.
 - It caters to the needs of small, medium and also for large organizations.
 - Salesforce works on used and pay methods, so there are no overhead costs.
 - Increase customer loyalty, retention, and satisfaction.
 - Salesforce can easily integrate with 3rd party apps.
 - Increase the growth of your business.
 - Continuous optimization of campaigns can be done based on the market response and closure interaction with channel partners.

What is APEX?

- Apex is an object-oriented programming language. It allows developers to execute transaction control and flow statements on Salesforce servers with the help of an API. Apex also helps developers to add business logic into their programming code.

Advantages of using Apex language:

- Apex uses syntax and semantics that are easy to understand and offers fast and effective results.
- It is designed to thread together multiple queries and DML statements into a single unit of work on the Salesforce server.
- Apex uses direct references to schema objects like object and field names.

Features of Salesforce:

- **Marketing and sales lead:** Helps you to measure customer engagement by tracking email activities and convert them to customers.
- **Contact management:** With the help of this feature you can pull your customer's data like activity history, frequent contacts, customer communications, etc.

- **Build and run innovative apps:** You can build, scale and manage apps.
- **Analytics:** It allows you to access the data, create dashboards and perform analysis
- **Email integration:** It provides integrations devoted to customer service, support and customer experience.
- **Communities for sales:** Online community software that enables companies to connect customers, partners and employees with each other.
- **Salesforce Engine:** This feature focuses on making personalized contact with a customer for various campaigns designed by the marketing team.
- **Sales Collaboration:** This feature helps you to address customer queries and feedback.
- **Sales Performance Management:** It offers a metric-based goal setting and helps you to get feedback and rewards for the sales team.
- **Lead Management:** This feature helps you to tracks the leads that are in progress.
- **Partnership management:** This feature allows you to build communities with partners and help them to share objectives, goals, and activities.
- **Workflow and Approvals:** The interface provides simple drag and drops option.
- **Files Sync and Share:** This feature provides the sales team the power to share various files and update them instantly.
- **Reports and Dashboards:** Dashboards and reporting feature offers a real-time picture of the business at a glance.
- **Sales Forecasting:** This feature allows you are getting a real time view of the forecast of a sales team.

2.5 EXPLORING PAAS – FORCE.COM

2.5.1 PaaS

- PaaS may be a set of cloud based services that enable business users and developers to create applications at a speed that on-premise solutions cannot match. As it's a cloud based service there's no need to worry about the set-up and maintenance of servers, patching, upgrades, authentication, and so on, users can just specialise in creating the best user experience possible. PaaS also delivers a group of additional services like workflow and style tools and rich APIs all intended to assist business users and developers create applications that delight their users.

2.5.2 Force.com

- Force.com is different from other PaaS solutions in its focus on business applications. Force.com is a part of Salesforce.com, which started as a SaaS Customer Relationship Management (CRM) vendor. But Force.com is not CRM. It provides the infrastructure commonly needed for any business application, customizable for the unique requirements of each business through a combination of code and configuration. This infrastructure is delivered to you as a service on the Internet.

- Force.com is targeted toward corporate application developers and independent software vendors. Unlike the other PaaS offerings, it does not expose developers directly to its own infrastructure. Developers do not provision CPU time, disk, or instances of running operating systems. Instead, Force.com provides a custom application platform centered on the relational database, one resembling an application server stack you might be familiar with from working with .NET, J2EE, or LAMP.
- Although it integrates with other technologies using open standards such as SOAP and REST, the programming languages and metadata representations used to build applications are proprietary to Force.com. This is unique among the PaaS products but not unreasonable when examined in depth. Force.com operates at a significantly higher level of abstraction than the other PaaS products, promising dramatically higher productivity to developers in return for their investment and trust in a single-vendor solution.
- To extend the reach of Force.com to a larger developer community, Salesforce and VMware provide a product called VMforce. VMforce brings some of the features of the Force.com platform to Java developers. It consists of development tools from the Salesforce community and virtualized computing resources from VMware. With VMforce, you can create hybrid applications that use Force.com for data and services, but are built with Java standard technologies such as Spring. Along the same lines, Salesforce's acquisition of Heroku is expected to extend Force.com features to Ruby developers.
- Force.com is free for developers. Production applications are priced primarily by storage used and number of unique users.

Force.com Services:

- Force.com can be divided into four major services: database, business logic, user interface, and integration. Technically there are many more services provided by Force.com, but these are the high-level categories that are most relevant to new Force.com developers.
 1. **Database:** Force.com is built around a relational database. It allows the definition of custom tables containing up to 500 fields. Fields contain strongly typed data using any of the standard data types, plus rich types such as currency amounts, picklists, and phone numbers. Fields can contain validation rules to keep data clean before it is committed and formulas to derive values like cells in a spreadsheet. Field history tracking provides an audit log of changes to chosen fields. Custom tables can be related to each other, allowing the definition of complex data schemas. Tables, rows, and columns can be configured with security constraints. Data and metadata is protected against accidental deletion through a "recycling bin" metaphor. The database schema is often modifiable instantly, without manual migration. Data is imported from files or other sources with free tools, and APIs are provided for custom data loading solutions.

2. **Business Logic:** Apex is the language used to implement business logic on Force.com. It allows code to be structured into classes and interfaces, and it supports object-oriented behaviors. It has strongly typed collection objects and arrays modeled after Java. Data binding is a first-class concept in Apex, with the database schema automatically imported as language constructs. Data manipulation statements, trigger semantics, and transaction boundaries are also part of the language.
3. **User Interface:** Force.com provides two approaches for the development of user interfaces: Page Layouts and Visualforce. **Page Layouts** are inferred from the data model, including validation rules, and then customized using a WYSIWYG editor. Page Layouts feature the standard Salesforce look-and-feel. For many applications, Page Layouts can deliver some or all of the user interface with no development effort. User interfaces in **Visualforce** are public, private, or some blend of the two. Private user interfaces require a user to log in before gaining access. Public user interfaces, called Sites, can be made available to anonymous users on the Internet.
4. **Integration:** In the world of integration, more options are usually better, and standards support is essential. Force.com supports a wide array of integration technologies, almost all of them based on industry-standard protocols and message formats. You can integrate other technologies with Force.com using the standard recipe of configuration plus code.

2.6 EXPLORING IAAS – AMAZON EC2

2.6.1 IaaS

- IaaS or Infrastructure-as-a-service is one of Amazon Web Services that focuses on providing infrastructure services based on cloud computing technology. IaaS Amazon Service is used to replace physical resources, such as servers, with virtual resources hosted and managed by Amazon.
- AWS Elastic Compute Service or EC2 is IaaS (Infrastructure as a Service). This is because Amazon takes the responsibility of networking, storage, server and virtualization and the user is responsible for managing the Operating System, middleware, runtime, data and application.

2.6.2 Amazon Elastic Compute Cloud (EC2)

- “Amazon Elastic Compute Cloud (Amazon EC2) is an Amazon Web Service (AWS) you can use to access servers, software, and storage resources across the Internet in a self-service manner”.
- Amazon Elastic Compute Cloud (Amazon EC2) is a web service that provides secure, resizable compute capacity in the cloud. It is designed to make web-scale cloud computing easier for developers.

- Amazon EC2's simple web service interface allows you to obtain and configure capacity with minimal friction. It provides you with complete control of your computing resources and lets you run on Amazon's proven computing environment.
- Amazon EC2 offers the broadest and deepest compute platform with choice of processor, storage, networking, operating system, and purchase model. We offer the fastest processors in the cloud and we are the only cloud with 400 Gbps ethernet networking. We have the most powerful GPU(Graphics Processing Unit) instances for machine learning training and graphics workloads, as well as the lowest cost-per-inference instances in the cloud. More SAP, HPC, Machine Learning, and Windows workloads run on AWS than any other cloud.

What is Amazon EC2 instance and how it works?

- An Amazon EC2 instance is a virtual server in Amazon's Elastic Compute Cloud (EC2) for running applications on the Amazon Web Services (AWS) infrastructure.
- Amazon provides various types of instances with different configurations of CPU, memory, storage and networking resources to suit user needs.
- EC2 setup involves creating an Amazon Machine Image (AMI), which includes an operating system, apps, and configurations. That AMI is loaded to the Amazon Simple Storage Service (S3), and it's registered with EC2, at which point users can launch virtual machines as needed.

Following are some examples to launch Instance:

1. AMI and Instance:

- Amazon Machine Image (AMI) is a template for software configuration (Operating System, Application Server, and Applications).
- Instance is an AMI running on virtual servers in the cloud.
- Each instance type offers different compute and memory facilities.

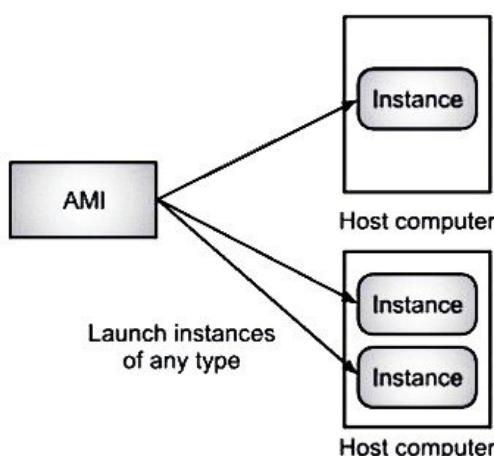


Fig. 2.7: AMI and Instance

2. Region and Zones:

- Amazon has data centers in different regions across the globe.
- An instance can be launched in different regions depending on the need.
 - Closer to specific customer.
 - To meet legal or other requirements.
- Each region has a set of zones.
- Zones are isolated from failure in other zones.
- Inexpensive, low latency connectivity between zones in same region.

3. Storage:

- Amazon EC2 provides three type of storage option:
 - Amazon EBS
 - Amazon S3
 - Instance Storage

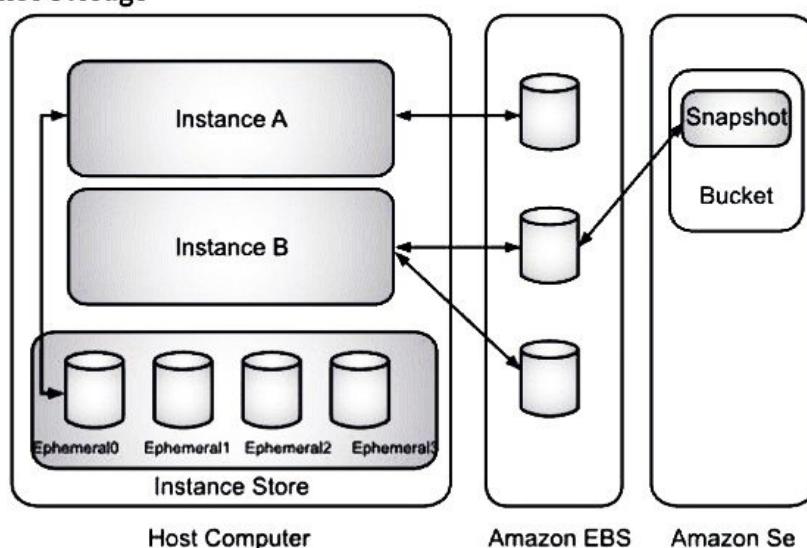


Fig. 2.8: Type of storage Amazon EC2

4. Networking and Security:

- Instances can be launched on one of the two platforms:
 - (i) **EC2-Classic:** EC2-Classic is the original release of Amazon EC2. With this platform, instances run in a single, flat network that is shared with other customers. With EC2-VPC, instances run in a virtual private cloud (VPC) that is logically isolated to only one AWS account.
 - (ii) **EC2-VPC:** Amazon Virtual Private Cloud (Amazon VPC) is a service that lets you launch AWS resources in a logically isolated virtual network that you define.
- Instance IP address is dynamic. New IP address is assigned every time an instance is launched.

- Static IP address – Elastic IP address.
 - Remap the Elastic IP to new instance to mask failure.
 - Separate pool for EC2-Classic and VPC.
- Security Groups to access control to instance.

5. Monitoring, Auto Scaling, and Load Balancing:

- (i) Amazon Web Services (AWS) automatically provides data that you can use to monitor your Amazon Elastic Block Store (Amazon EBS) volumes.
- (ii) CloudWatch collects monitoring and operational data in the form of logs, metrics, and events, and visualizes it using automated dashboards so you can get a unified view of your AWS resources, applications, and services that run in AWS and on-premises.
- Automatically scales amazon EC2 capacity up and down based on rules.
 - Add and remove resource based on demand.
 - Suitable for businesses experiencing variability in usage.
- Distribute incoming traffic across multiple instances.
 - Elastic Load Balancing offers the ability to load balance across AWS and on-premises resources.

Benefits of EC2

1. **Elastic Web-Scale Computing:** Amazon EC2 enables you to increase or decrease capacity within minutes, not hours or days. You can commission one, hundreds or even thousands of server instances simultaneously. Of course, because this is all controlled with web service APIs, your application can automatically scale itself up and down depending on its needs.
- (i) **Completely Controlled:** You have complete control of your instances. You have root access to each one, and you can interact with them as you would any machine. You can stop your instance while retaining the data on your boot partition and then subsequently restart the same instance using web service APIs. Instances can be rebooted remotely using web service APIs. You also have access to console output of your instances.
- (ii) **Flexible Cloud Hosting Services:** You have the choice of multiple instance types, operating systems, and software packages. Amazon EC2 allows you to select a configuration of memory, CPU, instance storage, and the boot partition size that is optimal for your choice of operating system and application. For example, your choice of operating systems includes numerous Linux distributions, and Microsoft Windows Server.
- (iii) **Designed for Use with Other Amazon Web Services:** Amazon EC2 works in conjunction with Amazon Simple Storage Service (Amazon S3), Amazon Relational

Database Service (Amazon RDS) and Amazon Simple Queue Service (Amazon SQS) to provide a complete solution for computing, query processing and storage across a wide range of applications.

(iv) **Reliable:** Amazon EC2 offers a highly reliable environment where replacement instances can be rapidly and predictably commissioned. The service runs within Amazon's proven network infrastructure and datacenters.

(v) **Secure:** Amazon EC2 works in conjunction with Amazon VPC to provide security and robust networking functionality for your computer resources. Your compute instances are located in a Virtual Private Cloud (VPC) with an IP range that you specify. You decide which instances are exposed to the Internet and which remain private.

Summary

- Virtualization is the "creation of a virtual (rather than actual) version of something, sort of a server, a desktop, a storage device , an OS or network resources".
- There are six areas of IT where virtualization is making headway: Network virtualization, Storage virtualization, Server virtualization, Data virtualization, Desktop virtualization, Application virtualization.
- Load balancing is the process of distributing traffic across your network of servers to make sure that the system doesn't get overwhelmed, and every one requests are handled easily and efficiently.
- Google Cloud Load Balancing is a fully distributed, software-defined managed service. It provides scaling, high availability, and traffic management for internet-facing and private applications.
- Global load balancing means backend endpoints live in multiple regions.
- Regional load balancing means backend endpoints live in a single region.
- External load balancing supports Instance groups, Zonal network endpoint groups (NEG), buckets in Cloud Storage, serverless NEG, and internet NEG. It can be used to support web, application, and database tier services.
- Internal load balancing is a managed service that can only be accessed on an internal IP address and in the chosen region of your Virtual Private Cloud network.
- A hypervisor also referred to as a virtual machine monitor or VMM, is software that makes and runs virtual machines (VMs). A hypervisor allows one host computer to support multiple guest VMs by virtually sharing its resources, like memory and processing.
- There are two types of hypervisors: Type 1 – hypervisor, Type 2 - hypervisor.

Check Your Understanding

1. Which of the following type of virtualization is also characteristic of cloud computing?

(a) Storage	(b) Application
(c) CPU	(d) All of the mentioned
2. The technology used to distribute service requests to resources is referred to as _____.

(a) load performing	(b) load scheduling
(c) load balancing	(d) All of the mentioned
3. Which of the following is a more sophisticated load balancer?

(a) Workload managers	(b) Workspace managers
(c) Rackserve managers	(d) All of the mentioned
4. The program which provides partitioning, isolation or abstraction is called?

(a) Virtualization hypervisor	(b) Software hypervisor
(c) Hardware hypervisor	(d) System hypervisor
5. A hypervisor is sometimes also called a _____?

(a) VMA	(b) VMS
(c) VMM	(d) VMR
6. Which of the following behaves like the entry point of the monitor and reroutes the instructions of the virtual machine?

(a) Dispatcher	(b) Allocator
(c) Interpreter	(d) Both (a) and (b)
7. Which of the following can be identified as a cloud?

(a) Web Applications	(b) Intranet
(c) Hadoop	(d) All of the mentioned
8. Cloud computing doesn't require that _____ and software be composable.

(a) cloud	(b) database
(c) hardware	(d) All of the mentioned
9. A _____ cloud requires virtualized storage to support the staging and storage of data.

(a) soft	(b) compute
(c) local	(d) None of the mentioned
10. Which of the following is not a type of virtualization?

(a) Full virtualization	(b) Para virtualization
(c) OS-level virtualization	(d) Physical virtualization

Answers

- | | | | | | | | | | |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| 1. (d) | 2. (c) | 3. (a) | 4. (a) | 5. (c) | 6. (a) | 7. (c) | 8. (d) | 9. (b) | 10. (d) |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|

Practice Questions**Q.I Answer the following questions in short.**

1. What is APEX?
2. What is AMI?
3. What is Amazon S3?
4. What are the types of Virtual Machine?
5. What is PaaS Salesforce?
6. What is difference between SaaS and PaaS?
7. What is the Amazon Web Service?
8. List AWS management tools used while using Amazon cloud services?
9. What do you mean by AWS Global Cloud Infrastructure?

Q.II Answer the following questions.

1. What is Virtual Machine Technology and benefits of Virtualization?
2. What are the different types of virtualizations in AWS, and what are the differences between them?
3. What is Cloud Computing Load Balancing and Scalability?
4. What are the AWS management tools used while using Amazon cloud services?
5. What are Amazon Cloud solutions?
6. What are the different service offerings provided by Amazon under Security Identity and compliance services?
7. How does Virtual Clustering work?
8. What is the difference between Esx Server and Vmware Server?
9. Elaborate on Analytics services offered by Amazon.
10. How is SaaS beneficial to Salesforce?

Q.III Define the terms.

1. Virtualization
2. Load Balancing
3. Hypervisors
4. Salesforce.com
5. Amazon EC2



3...

Programming Environment

Learning Objectives ...

- To learn features of Cloud and Grid Platform.
- To understand Programming Support of Google App Engine.
- To know about Programming on Amazon AWS.
- To understand Microsoft Azure.
- To learn Emerging Cloud Software Environments.

3.1 INTRODUCTION

- Cloud programming environments are online web-based applications designed to offer for development capabilities. They usually consist of a source code editor, a number of compilers or interpreters depending on the programming language, a debugger and a project/solution viewer for managing the independent subcomponents.
- Grid computing may be a sort of distributed computing that involves coordinating and sharing computing, application, data and storage or network resources across dynamic and geographically dispersed organization.
- Grid technologies promise to vary the way organizations tackle complex computational problems. The vision of grid computing was to permit access to computer based resources (from CPU cycles to data servers) within the same manner as world utilities. This gave rise to the thought of Virtual Organizations (VOs). Through the creation of VOs, it had been possible to access all resources as if all resources were owned by one organization.

3.2 FEATURES OF CLOUD AND GRID PLATFORMS

3.2.1 Features of Cloud Computing

1. **Resources Pooling:** It means the cloud provider pulled the computing resources to provide services to multiple customers with the help of a multi-tenant model. There

are different physical and virtual resources assigned and reassigned which depends on the demand of the customer. The customer generally has no control on information over things of the provided resources but during a position to specify location at a far better level of abstraction

2. **On-Demand Self-Service:** It is one of the important and valuable features of cloud computing because the user can continuously monitor the server uptime, capabilities, and allotted network storage.
3. **Easy Maintenance:** The servers are easily maintained and thus the downtime is extremely low and even in some cases, there is no downtime. Cloud computing comes up with an update whenever by gradually making it better. The updates are more compatible with the devices and perform faster than older ones in conjunction with the bugs which are fixed.
4. **Large Network Access:** The user can access the data of the cloud or upload the data to the cloud from anywhere just with the help of a tool and a web connection. These capabilities are available everywhere the network and accessed with the help of internet.
5. **Availability:** The capabilities of the cloud are often modified as per the use and should be extended lot. It analyzes the storage usage and allows the user to buy for extra cloud storage if needed for a very bit.
6. **Automatic System:** Cloud computing automatically analyzes the data needed and supports a metering capability at some level of services. We will monitor, control, and report the usage. It'll provide transparency for the host and the customer.
7. **Economical:** It is the one-time investment because the corporate (host) possesses to buy for the storage and a little part of it are often provided to the various companies which save the host from monthly or yearly costs. Only the amount which is spent is on the essential maintenance and a few of more expenses which are very less.
8. **Security:** Cloud security is one of the only features of cloud computing. It creates a snapshot of the data stored so that the data won't stray even if one of the servers gets damaged. The data is stored within the storage devices, which cannot be hacked and utilized by the unauthorized person. The storage service is quick and reliable.
9. **Pay-as-you-go:** In cloud computing, the user pays only for the service or the space they have utilized. There's no hidden or extra charge which is to be paid. The service is economical and most of the time some space is allotted for free of charge.
10. **Measured Service:** Cloud computing resources used to monitor and thus the corporate sector uses it for recording. This resource utilization is analyzed by supporting charge-per-use capabilities. This means that the resource usages which can be either virtual server instances that are running within the cloud are getting monitored, measured and reported by the service provider. The model pay-as-you-go is variable supported actual consumption of the manufacturing organization.

3.2.2 Features of Grid Computing

1. **Large scale:** A grid must be ready to affect a variety of resources starting from just a couple of to millions. This raises the very significant issue of avoiding potential performance degradation because the grid size increases.
2. **Geographical distribution:** Grid's resources could also be located at foreign places. Heterogeneity: a grid hosts both software and hardware resources which will be very varied starting from data, files, software components or programs to sensors, scientific instruments, display devices, personal digital organizers, computers, supercomputers and networks.
3. **Resource sharing:** Resources in a grid belong to many different organizations that allow other organizations (i.e. users) to access them. Nonlocal resources can thus be employed by applications, promoting efficiency and reducing costs.
4. **Multiple administrations:** Each organization may establish different security and administrative policies under which their owned resources are often accessed and used. As a result, the already challenging network security problem is complicated even more with the necessity of taking under consideration all different policies.
5. **Transparent access:** A grid should be seen as a single virtual computer. Dependable access: a grid must assure the delivery of services under established Quality of Service (QoS) requirements. The need for dependable service is prime since users require assurances that they're going to receive predictable, sustained and sometimes high levels of performance.
6. **Consistent access:** A grid must be built with standard services, protocols and interfaces thus hiding the heterogeneity of the resources while allowing its scalability. Without such standards, application development and pervasive use wouldn't be possible.
7. **Pervasive access:** The grid must grant access to available resources by adapting to a dynamic environment during resource failure is commonplace. This doesn't imply that resources are everywhere or universally available but that the grid must tailor its behavior to extract the utmost performance from the available resources.

Table 3.1: Difference between Cloud Computing and Grid Computing

SR. No	Cloud Computing	Grid Computing
1.	Cloud computing is a client-server computing architecture.	Grid computing is a distributed computing architecture.
2.	Cloud computing is a centralized executive.	While grid computing is a decentralized executive.

Contd...

3.	In cloud computing, resources are used in centralized pattern.	In grid computing, resources are used in collaborative pattern.
4.	It is more flexible than grid computing.	It is less flexible than cloud computing.
5.	In cloud computing, the users pay for the use.	In grid computing, the users do not pay for use.
6.	Cloud computing is a high accessible service.	Grid computing is a low accessible service.
7.	It is highly scalable as compared to grid computing.	It is low scalable in comparison to cloud computing.
8.	It can be accessed through standard web protocols.	It is accessible through grid middleware.

3.3 PROGRAMMING SUPPORT OF GOOGLE APP ENGINE

- Google's App Engine (GAE) offers a PaaS platform supporting various cloud and web applications.
- The company has novel programming models that scale to incredible sizes. Google has hundreds of data centers and has installed more than 460,000 servers worldwide. For example, 200 Google data centers are used at one time for a number of cloud applications. Data items are stored in text, images, and video and are replicated to tolerate faults or failures.

3.3.1 Programming the Google App Engine

- GAE programming model supported for two languages: Java and Python. A client environment includes an Eclipse plug-in for Java that allows you to debug your GAE on your local machine. Google Web Toolkit is available for Java web application developers. Python is employed with frameworks like Django and CherryPy, but Google also has webapp Python environment.
- There are several powerful constructs for storing and accessing data. The data store may be a NoSQL data management system for entities. Java offers Java Data Object (JDO) and Java Persistence API (JPA) interfaces implemented by the Data Nucleus Access platform, while Python has a SQL-like query language called GQL. The performance of the info store is often enhanced by in-memory caching using the memcache, which may even be used independently of the info store.

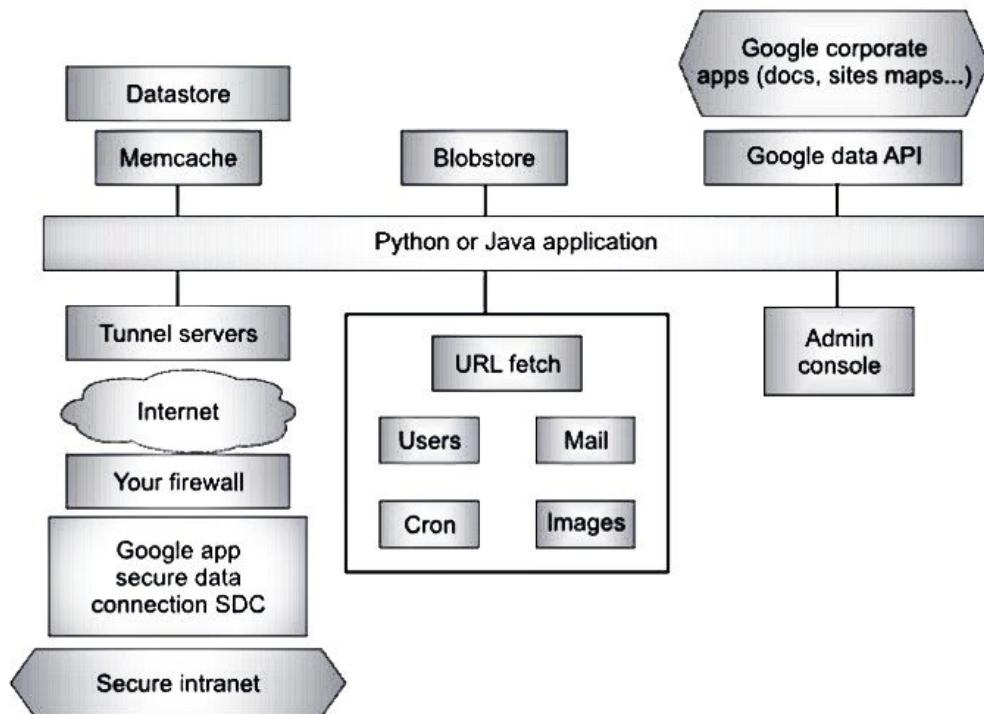


Fig. 3.1: Programming Environment Google App Engine

- Recently, Google added the blobstore which is suitable for giant files as its size limit is 2GB. There are several mechanisms for incorporating external resources. The Google SDC (Secure Data Connection) can tunnel through the web and link your intranet to an external GAE application. The URL fetch operation provides the ability for applications to fetch resources and communicate with other hosts over the Internet using HTTP and HTTPS requests. An application can use Google Accounts for user authentication. Google Accounts handles user account creation and sign-in, and a user that already has a Google account (such as a Gmail account) can use that account together with your app.
- GAE provides the ability to manipulate image data using a dedicated images service which can resize, rotate, flip, crop, and enhance images. A GAE application is configured to consume resources up to certain limits or quotas. With quotas, GAE ensures that your application won't exceed your budget, and that other applications running on GAE won't impact the performance of your app. In particular, GAE use is free up to certain quotas.

3.3.2 Google File System (GFS)

- GFS is a fundamental storage service for Google's search engine. GFS was designed for Google applications, and Google applications were built for GFS.
- There are several concerns in GFS. As servers are composed of inexpensive commodity components, it is the norm rather than the exception that concurrent

failures will occur all the time. Another concern is the file size in GFS. GFS typically will hold a large number of huge files, each 100 MB or larger, with files that are multiple GB in size quite common. Thus, Google has chosen its file data block size to be 64 MB rather than 4 KB in typical traditional file systems.

- The I/O pattern within the Google application is additionally special. Files are typically written once, and therefore the write operations are often the appending data blocks to the top of files. Multiple appending operations might be concurrent. The customized API can simplify the matter and specialise in Google applications.
- Fig. 3.2 shows the GFS architecture. It is quite obvious that there's one master within the whole cluster. Other nodes act as the chunk servers for storing data, while the single master stores the metadata. The file system namespace and locking facilities are managed by the master. The master periodically communicates with the chunk servers to collect management information as well as give instructions to the chunk servers to do work such as load balancing or fail recovery.

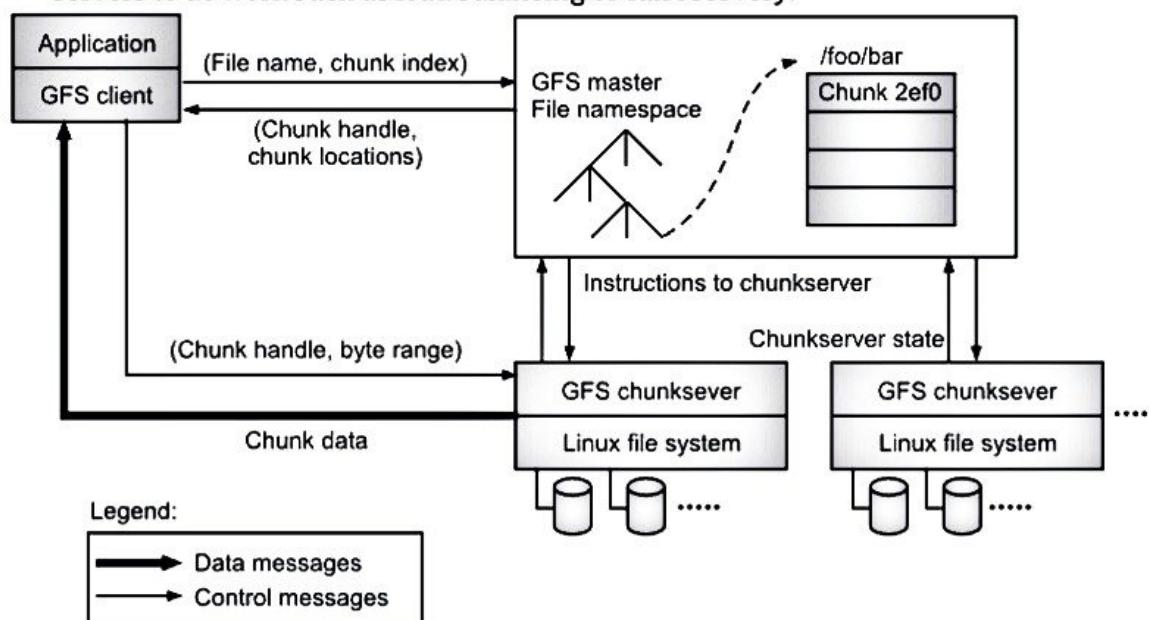


Fig. 3.2: GFS Architecture

- The master has enough information to stay the entire cluster during a healthy state. Google uses a shadow master to replicate all the data on the master, and the design guarantees that all the data operations are performed directly between the client and the chunk server. The control messages are transferred between the master and the clients and they can be cached for future use. With the present quality of commodity servers, the only master can handle a cluster of quite 1,000 nodes.
- Fig. 3.3 shows the data mutation (write, append operations) in GFS. Data blocks must be created for all replicas.

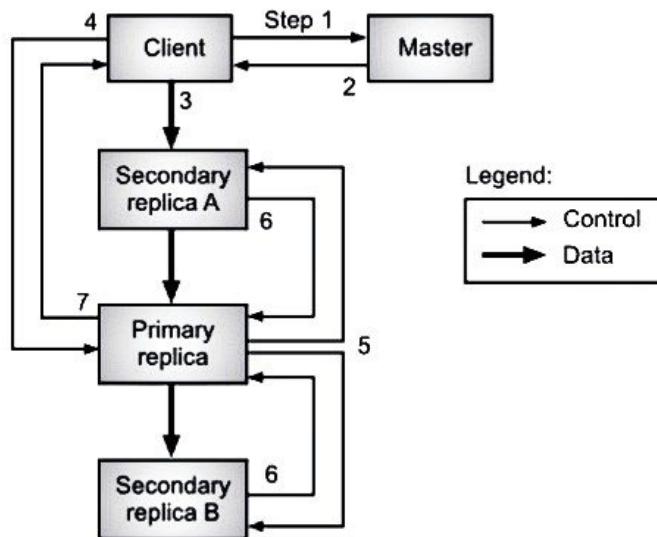


Fig. 3.3: Data Mutation (Write, Append Operations) in GFS

- The goal is to minimize involvement of the master. The mutation takes the following steps:
 1. The client asks the master which chunk server holds the present lease for the chunk and therefore the locations of the other replicas. If nobody has a lease, the master grants one to a replica it chooses (not shown).
 2. The master replies with the identity of the first and the locations of the other (secondary) replicas. The client caches this data for future mutations. It must contact the master again only if the first becomes unreachable or replies that it does not hold a lease.
 3. The client pushes the data to all the replicas. Each chunk server will store the info in an indoor LRU buffer cache until the info is employed or aged out. By decoupling the data flow from the control flow, we can improve performance by scheduling the expensive data flow based on the network topology regardless of which chunk server is the primary.
 4. Once all the replicas have acknowledged receiving the info, the client sends a write request to the first. The request identifies the info pushed earlier to all or any of the replicas. The primary assigns consecutive serial numbers to all or any of the mutations it receives, possibly from multiple clients, which provides the required serialization. It applies the mutation to its own local state in serial order.
 5. The primary forwards the write request to all or any secondary replicas. Each secondary replica applies mutations within the same serial number order assigned by the first.
 6. The secondaries all reply to the first indicating that they need completed the operation.

7. The primary replies to the client. Any errors encountered at any of the replicas are reported to the client. In case of errors, the write may have succeeded at the primary and an arbitrary subset of the secondary replicas. (If it had failed at the primary, it would not have been assigned a serial number and forwarded.) The client request is considered to have failed, and the modified region is left in an inconsistent state. Our client code handles such errors by retrying the failed mutation. It will make a few attempts at steps (3) through (7) before falling back to a retry from the beginning of the write.

3.3.3 Big Table

- Cloud Big Table can scale to billions of rows and thousands of columns, enabling you to store terabytes or even petabytes of data. A single value in each row is indexed; this value is known as the row key. Big table is ideal for storing very large amounts of single-keyed data with very low latency. It supports high read and write throughput at low latency and it is an ideal data source for MapReduce operations.
- Big table is exposed to applications through multiple client libraries, including a supported extension to the Apache HBase library for Java. It integrates with the existing Apache ecosystem of open-source Big Data software.
- You can use Big table to store and query all of the following types of data:
 - Time-series data, such as CPU and memory usage over time for multiple servers.
 - Marketing data, such as purchase histories and customer preferences.
 - Financial data, such as transaction histories, stock prices, and currency exchange rates.
 - Internet of Things data, such as usage reports from energy meters and home appliances.
 - Graph data, such as information about how users are connected to one another.

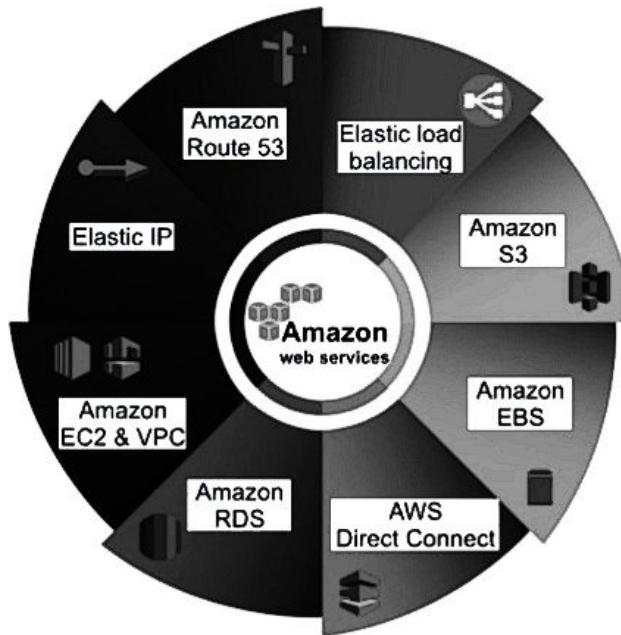
3.4 PROGRAMMING ON AMAZON AWS

What is AWS?

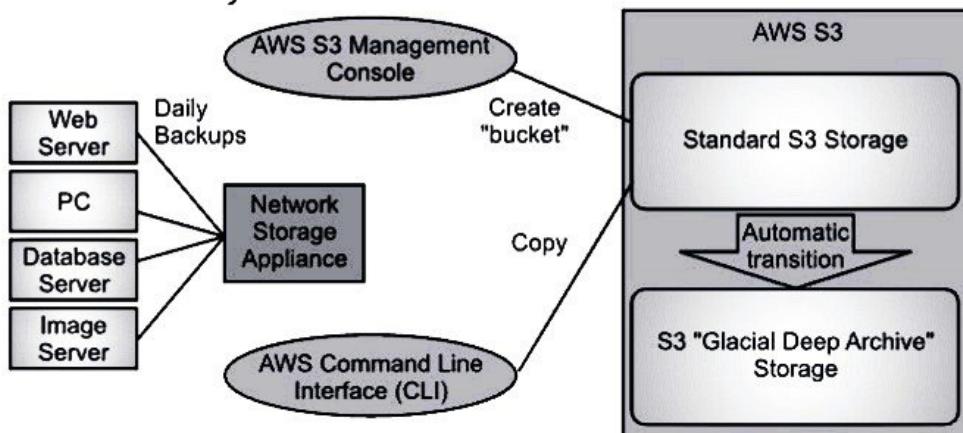
- Amazon Web Service (AWS) may be a platform that gives flexible, reliable, scalable, easy-to-use and cost-effective cloud computing solutions.
- The platform is developed with a mixture of infrastructure-as-a-service (IaaS), platform-as-a-service (PaaS) and packaged software-as-a-service (SaaS) offerings.

Important AWS Services:

- Amazon Web Services offers a good range of various business purpose global cloud-based products. The products include storage, databases, analytics, networking, mobile, development tools, enterprise applications, with a pay-as-you-go pricing model.

Amazon Web Services:**Fig. 3.4: Amazon Web Services****1. Amazon Simple Storage Service (S3):**

- Amazon S3 is storage for the Internet. It's a simple storage service that offers software developers a highly-scalable, reliable, and low-latency data storage infrastructure at very low costs.

**Fig. 3.5: Amazon Simple Storage Service (S3)**

- Amazon S3 provides an easy web services interface which we can use to store and retrieve any amount of data at any time from anywhere on the online. S3 provides the object oriented storage service for users. Users can access their objects through Simple Object Access Protocol (SOAP) with either browsers or other client programs which support SOAP.

- The fundamental operation unit of S3 is named an object. Each object is stored during a bucket and retrieved via a unique developer-assigned key. In other words, the bucket is that the container of the thing. Besides unique key attributes, the thing has other attributes like values, metadata, and access control information. Through the key-value programming interface, users can write, read, and delete objects containing from 1 byte to five gigabytes of knowledge each. There are two types of web service interface for the user to access the data stored in Amazon clouds. One is a REST (web 2.0) interface, and the other is a SOAP interface.
- Here are some key features of S3:
 - Redundant through geographic dispersion.
 - Designed to provide 99.99% durability and 99.99 % availability of objects over a given year with cheaper reduced redundancy storage (RRS).
 - Authentication mechanisms to make sure that data is kept secure from unauthorized access. Objects are often made private or public, and rights are often granted to specific users.
 - Per-object URLs and ACLs (Access Control Lists).
 - Default download protocol of HTTP.

2. Amazon Elastic Block Store (EBS):

- The Elastic Block Store (EBS) provides the volume block interface for saving and restoring the virtual images of EC2 instances. The status of EC2 can now be saved in the EBS system after the machine is shut down. Users can use EBS to save persistent data and mount to the running instances of EC2. Multiple volumes are often mounted to an equivalent instance. These storage volumes behave like raw, unformatted block devices, with user-supplied device names and a block device interface.

3. Amazon SimpleDB Service:

- SimpleDB provides a simplified data model supported by the electronic database data model. Structured data from users must be organized into domains. Each domain can be considered a table. The items are the rows within the table. A cell within the table is recognized because the value for a selected attribute (column name) of the corresponding row. It is possible to assign multiple values to one cell within the table. This is not permitted during a traditional electronic database. SimpleDB, like Azure Table, might be called "LittleTable" as they're aimed toward managing small amounts of data stored during a distributed table.

4. Elastic Compute Cloud (EC2):

- Amazon Elastic Compute Cloud (EC2) is a virtual server platform that allows users to create and run virtual machines on Amazon's server farm. You can launch and run server instances called Amazon Machine Images (AMIs) running different operating systems such as Red Hat Linux and Windows. The term elastic refers to the ability to size your capacity quickly as needed.

3.5 MICROSOFT AZURE

- Azure is Microsoft's cloud platform, a bit like Google has its Google Cloud and Amazon has its Amazon Web Service or AWS. Generally, it's a platform through which we will use Microsoft's resources. For example, to line up an enormous server, we'll require huge investment, effort, physical space then on. In such situations, Microsoft Azure comes to our rescue. It will provide us with virtual machines, fast processing of knowledge, analytical and monitoring tools then on to form our work simpler. The pricing of Azure is additionally simpler and cost-effective. Popularly termed as "Pay As You Go", which suggests what proportion you employ, pay just for that.
- Azure may be a public cloud computing platform with solutions including IaaS, PaaS, and SaaS which will be used for services like analytics, virtual computing, storage, networking, and far more. It can be used to replace or supplement your on-premise servers.

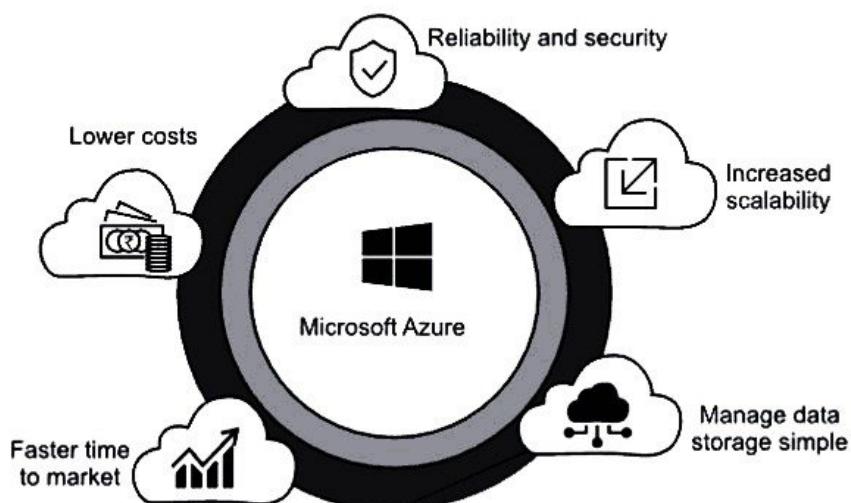


Fig. 3.6: Microsoft Azure

Azure History

- Microsoft unveiled Windows Azure in early October 2008 but it visited live after February 2010. Later in 2014, Microsoft changed its name from Windows Azure to Microsoft Azure. Azure provided a service platform for .NET services, SQL Services, and lots of Live Services. Many people were still very skeptical about "the cloud". As an industry, we were entering a brave new world with many possibilities. Microsoft Azure is getting bigger and better in coming days. More tools and more functionality are becoming added. It has two releases as of now. It is famous version of Microsoft Azure v1 and later Microsoft Azure v2. Microsoft Azure v1 was more like JSON script driven then the remake v2, which has interactive UI for simplification and straightforward learning. Microsoft Azure v2 remains within the preview version.

How Azure can help in business?

- Azure can help in our business in the following ways:
 - **Capitalless:** We don't need to worry about the capital as Azure cuts out the high cost of hardware. You simply pay as you go and luxuriate in a subscription-based model that's kind to your income. Also, to line up an Azure account is extremely easy. You simply register in Azure Portal and choose your required subscription and obtain going.
 - **Less operational cost:** Azure has low operational cost because it runs on its own servers whose only job is to form the cloud functional and bug-free, it's usually a whole lot more reliable than your own, on-location server.
 - **Cost effective:** If we found a server on our own, we'd like to rent a tech support team to watch them and confirm things are working fine. Also, there could be a situation where the tech support team is taking an excessive amount of time to unravel the difficulty incurred within the server. So, in this regard is much too pocket-friendly.
 - **Easy copy and Recovery options:** Azure keeps backups of all of your valuable data. In disaster situations, you'll recover all of your data during one click without your business getting affected. Cloud-based backup and recovery solutions save time, avoid large up-front investment and roll up third-party expertise as a neighborhood of the deal.
 - **Easy to implement:** It's very easy to implement your business models in Azure. With a few on-click activities, you're good to travel.
 - **Better security:** Azure provides more security than local servers. Be carefree about your critical data and business applications. As it stays safe within the Azure Cloud. Even, in natural disasters, where the resources are often harmed, Azure may be a rescue. The cloud is always on.
 - **Work from anywhere:** Azure gives you the liberty to figure from anywhere and everywhere. It just requires a network connection and credentials. And with most serious Azure cloud services offering mobile apps, you're not restricted to which device you've got to hand.
 - **Increased collaboration:** With Azure, teams can access, edit and share documents anytime, from anywhere. They can work and achieve future goals in hand. Another advantage of the Azure is that it preserves records of activity and data. Timestamps are one example of the Azure's record keeping. Timestamps improve team collaboration by establishing transparency and increasing accountability.

Table 3.2: Difference between AWS (Amazon Web Services), Google Cloud and Azure

Parameters	AWS	Google Cloud	Azure
Technology	EC2 (Elastic Compute Cloud)	Google Compute Engine (GCE)	VHD (Virtual Hard Disk)
Databases Supported	AWS fully supports relational and NoSQL databases and Big Data.	Technologies pioneered by Google, like Big Query, Big Table, and Hadoop, are naturally fully supported.	Azure supports both relational and NoSQL databases, and Big Data, through Windows Azure Table and HDInsight.
Pricing	Per hour - rounded up.	Per minute - rounded up (minimum 10 minutes).	Per minute - rounded up commitments (prepaid or monthly).
Models	On demand, reserved, spot.	On demand — sustained use.	On demand — short term commitments (prepaid or monthly).
Difficulties	Many enterprises find it difficult to understand the company's cost structure.	Fewer features and services.	Less "enterprise-ready"
Storage Services	Following are the storage services of AWS: <ul style="list-style-type: none"> • Simple Storage Service (S3) • Elastic Block Storage (EBS) 	Following are the storage services of Google Cloud: <ul style="list-style-type: none"> • Blob Storage • Queue Storage • File Storage • Disk Storage • Data Lake Store 	Following are the storage services of Azure: <ul style="list-style-type: none"> • Cloud Storage • Persistent Disk • Transfer Appliance
Machine Learning	AWS Services: <ul style="list-style-type: none"> • Sage Maker • Lex • Polly • And many more 	Google cloud services: <ul style="list-style-type: none"> • Machine Learning • Azure Bot Service • Cognitive Service 	Azure Services: <ul style="list-style-type: none"> • Cloud Speech API • Cloud Video Intelligence • Cloud Machine Learning Engine • And many more

3.6 EMERGING CLOUD SOFTWARE ENVIRONMENTS

- In this section, we will assess popular cloud operating systems and emerging software environments. We cover the open source Eucalyptus and Nimbus.

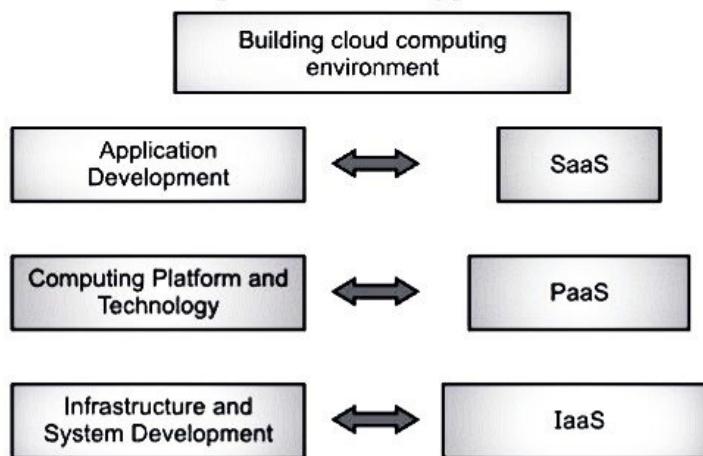


Fig. 3.7: Emerging Cloud Software Environments.

- Development of cloud computing applications happens by leveraging platforms & frameworks that provide different types of services, from the bare metal infrastructure to customizable applications servicing specific purposes.
- Various such platforms or technologies (PaaS) that are available for the users to create and host an application are: Amazon Web Services, Google AppEngine, Microsoft Azure.
- Cloud computing environment may be a new, great approach to providing IT-related services. In fact, this approach may be a dream of various business owners who wish to urge all possible IT services at one place. In the era of informational society this type of services is becoming more and more popular, because it helps entrepreneurs resolve all IT challenges within one company quickly and efficiently.
- In simple terms, the cloud computing environment is all about IT and what IT needs: different kinds of software and hardware, pay-per-use or subscription-based services offered both through the Internet and in real time.
- The emergence of cloud computing has reduced the value of deployment and storage dramatically, but as long as data are often distributed across multiple servers easily without disruption. In a complex SQL database, this is often difficult because many queries require multiple large tables to be joined together to supply a response. Executing distributed joins may be a very complex problem in SQL databases. In addition, previous studies have shown that NoSQL databases perform better than SQL databases especially within the cloud computing environment where there's occurrence of giant volume of knowledge.

- Because all businesses are unique they'll require unique software to perform their tasks. It is often very costly and ineffective to get pricey tools which you're getting to use partly. For this reason there are SaaS companies, like isutility.com. Software as a service firms help resolve any issue regarding software required for your particular service. These companies license various applications on a pay-per-use base or a subscription.

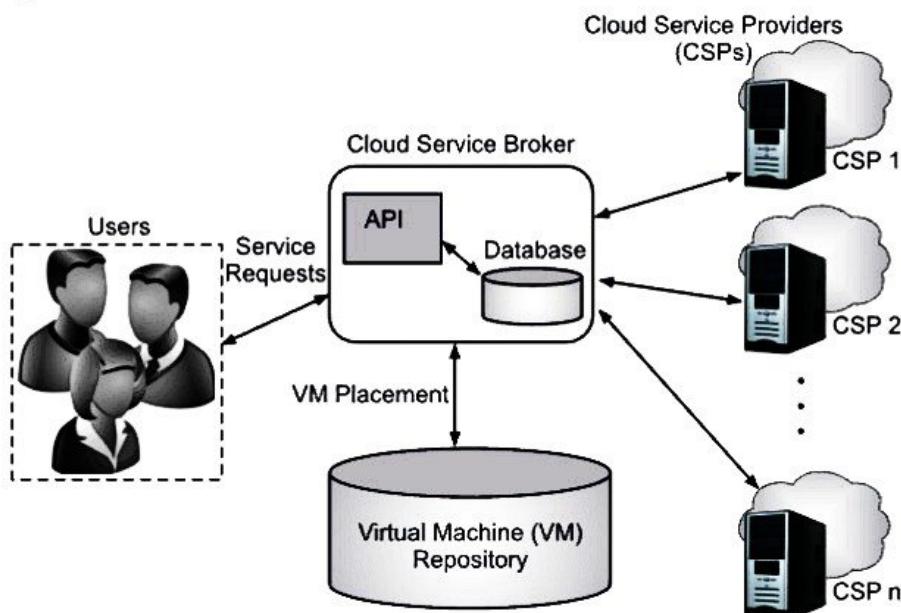


Fig. 3.8: Cloud Computing Environment

Cloud Computing Environment:

- Utility Computing:** This service is perhaps the foremost popular element of the cloud computing environment. It implies ability to access virtual storages, also as purchase capacity on the remote servers (this option is more popular than buying specific machines). Utility computing may be a provisioning model that maximizes the efficiency of the used service by minimizing IT-related budget. The term 'utility' is employed as an analog to other services, like electric power, where customers buy consumed products instead of a flat rate. This approach is additionally referred to as 'metered service'.

Open Source Software Environment:

1. Open Source Eucalyptus and Nimbus:

- The Eucalyptus system is an open software environment. Eucalyptus is a product from Eucalyptus Systems that was developed out of a research project at the University of California, Santa Barbara. Eucalyptus was initially aimed at bringing the cloud computing paradigm to academic supercomputers and clusters.

- Eucalyptus provides an AWS-compliant EC2-based web service interface for interacting with the cloud service. Additionally, Eucalyptus provides services, such as the AWS-compliant Walrus, and a user interface for managing users and images.
- Eucalyptus takes many design queues from Amazon's EC2, and its image management system is no different. Eucalyptus stores images in Walrus, the block storage system that is analogous to the Amazon S3 service. Such as, any user can bundle their own root file system, and upload and then register this image and link it with a particular kernel and ramdisk image. This image is uploaded into a user-defined bucket within Walrus, and can be retrieved anytime from any availability zone. This allows users to create specialty virtual appliances and deploy them within Eucalyptus with ease. The Eucalyptus system is available in a commercial proprietary version, as well as the open source version we just described.
- Nimbus is a set of open source tools that together provide an IaaS cloud computing solution. Nimbus provides a special web interface known as Nimbus Web. Its aim is to provide administrative and user functions in a friendly interface. Nimbus Web is centered around a Python Django web application that is intended to be deployable completely separate from the Nimbus service.
- Nimbus supports two resource management strategies. The first is the default "resource pool" mode. In this mode, the service has direct control of a pool of VM manager nodes and it assumes it can start VMs. The other supported mode is called "pilot." Here, the service makes requests to a cluster's Local Resource Management System (LRMS) to get a VM manager available to deploy VMs. Nimbus also provides an implementation of Amazon's EC2 interface that allows users to use clients developed for the real EC2 system against Nimbus-based clouds.

2. OpenNebula:

- OpenNebula is an open source toolkit which allows users to transform existing infrastructure into an IaaS cloud with cloud-like interfaces.
- OpenNebula is a cloud computing platform for managing heterogeneous distributed data center infrastructures. The OpenNebula platform manages a data center's virtual infrastructure to build private, public and hybrid implementations of Infrastructure as a Service. The two primary uses of the OpenNebula platform are data center virtualization and cloud deployments.
- OpenNebula is widely used by a variety of industries including cloud providers, telecommunication, information technology services, government, banking, gaming, media, hosting, supercomputing, research laboratories, and international research projects.
- Additionally, OpenNebula offers management interfaces to integrate the core's functionality within other data-center management tools, such as accounting or monitoring frameworks.

- OpenNebula currently includes an EC2 driver, which can submit requests to Amazon EC2 and Eucalyptus, as well as an ElasticHosts driver. Regarding storage, an Image Repository allows users to easily specify disk images from a catalog without worrying about low-level disk configuration attributes or block device mapping. Also, image access control is applied to the images registered in the repository, hence simplifying multiuser environments and image sharing. Nevertheless, users can also set up their own images.

Table 3.3: Comparison of Euclptus, Opennebula and Nimbus

Parameters	Euclptus	Opennebula	Nimbus
Philosophy	Mimic Amazon EC2.	Private, highly customizable cloud.	Cloud resources tailored to scientific researchers.
Customizability	Some for admin, less for user.	Basically everything.	Many parts except for image storage and globus credentials.
DHCP (Dynamic Host Configuration Protocol)	On cluster controller	Variable	On individual compute node.
Internal Security	Tight, Root required for many things.	Looser, but can be made more tight if needed.	Fairly tight, unless deploying a full private cloud.
User Security	Users are given custom credentials via web interface.	User logs into head.	Users x 509 credential is registered with cloud.
An ideal setting	Large group of machines for bunch of semi-trusted users.	Smaller group of machines for highly trusted users.	Deploy for less to semi trusted users familiar with x509.

Summary

- GAE programming model for two supported languages: Java and Python. A client environment includes an Eclipse plug-in for Java that allows you to debug your GAE on your local machine.
- GFS is a fundamental storage service for Google's search engine. GFS was designed for Google applications, and Google applications were built for GFS.

- Cloud Big table can scale to billions of rows and thousands of columns, enabling you to store terabytes or even petabytes of data.
- Bigtable is ideal for storing very large amounts of single-keyed data with very low latency.
- Amazon Web Services offers a good range of various business purpose global cloud-based products. The products include storage, databases, analytics, networking, mobile, development tools, enterprise applications, with a pay-as-you-go pricing model.
- The Elastic Block Store (EBS) provides the volume block interface for saving and restoring the virtual images of EC2 instances.
- SimpleDB provides a simplified data model supported by the electronic database data model.
- Amazon Elastic Compute Cloud (EC2) is a virtual server platform that allows users to create and run virtual machines on Amazon's server farm.
- Azure is Microsoft's cloud platform.
- The Eucalyptus system is an open software environment. Eucalyptus is a product from Eucalyptus Systems that was developed out of a research project at the University of California, Santa Barbara. Eucalyptus was initially aimed at bringing the cloud computing paradigm to academic supercomputers and clusters.
- Nimbus is a set of open source tools that together provide an IaaS cloud computing solution. Nimbus provides a special web interface known as Nimbus Web. Its aim is to provide administrative and user functions in a friendly interface. Nimbus Web is centered around a Python Django web application that is intended to be deployable completely separate from the Nimbus service.
- OpenNebula is an open source toolkit which allows users to transform existing infrastructure into an IaaS cloud with cloud-like interfaces.

Check Your Understanding

1. What is true about Grid Computing?
 - (a) Breaks complex tasks into smaller pieces
 - (b) Combine smaller tasks into complex tasks
 - (c) Subscription tier play vital role in Grid Computing
 - (d) Both (a) and (b)
2. Cloud computing product named Elastic Compute was released in the year _____.
 - (a) 2006
 - (b) 2000
 - (c) 2007
 - (d) 2010
3. Microsoft Azure was released by _____ vendor.
 - (a) Microsoft
 - (b) IBM
 - (c) Amazon
 - (d) Dell

4. Which of the following is mostly used by Microsoft Azure?
(a) Linux (b) Microsoft
(c) Azure (d) All the above
5. Which of the following allows you to create instances of the MySQL database to support your Web sites?
(a) Amazon Elastic Compute Cloud
(b) Amazon Simple Queue Service
(c) Amazon Relational Database Service
(d) Amazon Simple Storage System
6. Which of the following is a structured data store that supports indexing and data queries to both EC2 and S3?
(a) CloudWatch (b) Amazon SimpleDB
(c) Amazon Cloudfront (d) All of the mentioned
7. Cloud computing is a kind of abstraction that is based on the notion of combining physical resources and represents them as _____ resources to users.
(a) Virtual (b) Real
(c) Cloud (d) None of the mentioned
8. Cloud computing is a _____ system and it is necessarily unidirectional in nature.
(a) Reliable system (b) Stateless system
(c) Stateful system (d) None of the above
9. Which of these should a company consider before implementing cloud computing technology?
(a) Employee satisfaction (b) Potential cost reduction
(c) Information sensitivity (d) All of the above
10. What is Cloud Foundry?
(a) VMware-led open source PaaS
(b) A factory that produces cloud components
(c) An industry wide PaaS initiative
(d) None of the above

Answers

- | | | | | | | | | | |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|
| 1. (a) | 2. (a) | 3. (a) | 4. (a) | 5. (c) | 6. (b) | 7. (a) | 8. (b) | 9. (b) | 10. (a) |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|

Practice Questions

Q.I Answer the following questions in short.

1. What are the features of Cloud Computing?
2. What is Grid Computing?
3. How is Google App Engine used?

4. Is Google App Engine a SaaS?
5. What is the difference between Google App Engine and Google Compute Engine?
6. Explain what AWS is?
7. How many buckets can you create in AWS by default?
8. Explain what S3 is?
9. What is meant by Microsoft Azure?
10. What are emerging cloud software environments?

Q.II Answer the following questions.

1. What are the main features of Cloud Services?
2. What is computational Grid? Why it is needed?
3. What is the difference between Google App Engine and Google Compute Engine?
4. What is the difference between Amazon S3 and EC2?
5. What are the key components of AWS?
6. Mention what the security best practices for Amazon EC2?
7. What are the main functions of the Azure Cloud Service?
8. Explain the Window Azure platform?
9. What are the sizes of the Azure VM?
10. What are the different emerging technologies in cloud computing?

Q.III Define the terms.

1. Grid Computing
2. Google App Engine
3. Amazon AWS
4. Azure VM
5. Cloud Computing Environment

❖❖❖

4...

Deploying Applications and Cloud Services

Learning Objectives ...

- To know about Cloud Migration.
- To know about Microsoft Cloud Services.
- To learn about Google Cloud Services.
- To get familiar with Amazon Cloud Services.

4.1 INTRODUCTION

- In today's era cloud computing is playing a prominent role in almost all sectors because of its cost effectiveness, flexibility and efficiency many organizations are shifting their applications over the cloud.
- The process of moving applications from local to the cloud environments is referred to as Migration.
- In this process all data and applications are transformed from a local or on-premises data center to the cloud.
- This is not as easy as 'Lift and Shift'; many things need to be considered during migration.
- There are many cloud service providers available in the market like Microsoft Azure, Google Cloud Services, Amazon Web Services etc.

4.2 MOVING APPLICATION TO CLOUD

- The important aspects for moving applications to the cloud are to improve the operational performance, flexibility, workload scalability, and security of application as well as data.
- On demand usage of the resources is the cost effective solution for businesses but it should be strategic or well planned.

(4.1)

- Before moving towards cloud it is necessary to have clarity of your business goals so that you can look for the optimal solution or services from the cloud service providers.
- It is necessary to prepare a strategy that, what should be the part of cloud? and what is not, strategic plan will help you to reduce the post migration efforts.
- Choosing secure and trusted cloud service provider is also a challenging task but if you have very clear idea about requirement of your applications it will be easier task for you.

4.2.1 What is Cloud Migration?

- Cloud migration is the process of moving data, applications or other business elements to a cloud computing environment.

Steps involved in the cloud migration:

- Seven steps model is helpful to prepare an action plan of the migration process.

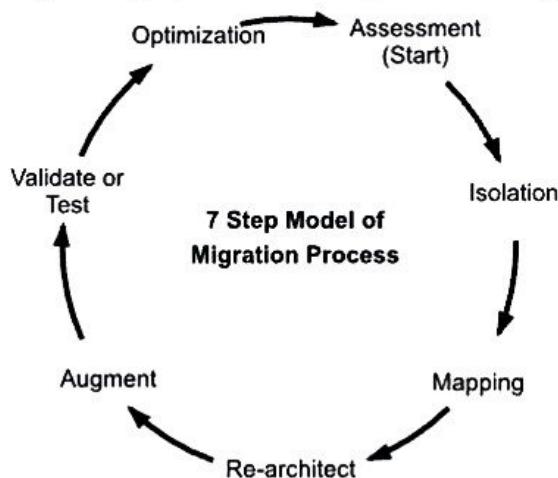


Fig. 4.1: Seven Step Model of Migration Process

- Following are the iterative steps, each of these step plays very important role in the Migration Process.

1. Assessment:

- Assessment is the first step of the iterative seven-step model migration process.
- It is focusing on the overall requirement of cloud resources as well as cost requirement of migration at the assessment level.
- This step includes assessment at code, design, and architecture levels.
- Assessments are also required for tools being used with their functionality, different test cases, and configuration of the application.

2. Isolation:

- Isolation is the second iterative step where dependencies between different modules are to be identified.
- This step isolates different dependent enterprise application components. These include library, application, and architectural dependencies.
- This step intern in a better understanding of the complexity of the migration.

3. Mapping:

- After isolation step it get decided what components should reside in a captive data center and what components should go on to the cloud.

4. Re-Architect:

- Consequently there may be chances of losing functionality because of isolation and other migration stuff.
- To avoid loss in the functionality some part of the application has to be re-architected, redesigned and implemented in the cloud environment.
- It is possible to approximate lost functionality using cloud runtime support API.

5. Augment:

- In this step, we have to extend several features of our application as per drastically changing environment.
- The internal features of the cloud computing service to augment our enterprise application in its own small ways.

6. Validate or Test:

- After successful augmentation it is necessary to test or validate our application to check whether its working as per expectations or not.
- In this step, we validate or test the new version of our enterprise application with an extensive test suite that covers testing the components of the enterprise application on the cloud environment.

7. Optimization:

- In this step after validation we optimize it as possible.
- As its iterative process after several iterations, the migration is considered to be successful.

4.2.2 Benefits of Cloud Migration

- **Easy for scalability:** You can easily scale computing resources as per increasing demand.
- **Cost Reduction:** Operational cost gets reduced.
- **Pay as per usage:** pay-as-you-go model, which is an attractive benefit, especially for startups.

- **Remote Access:** Cloud computing environments allow remotely located employees to access applications and work via the internet (Work from Home).
- **Easy upgradation:** Software as well as hardware up-gradation everything can be handled by cloud service provider.
- **More focus on development:** You can give more focus on application performance and development not on resources.

4.2.3 Risk of Cloud Migration

- **Data Sensitivity:** For several organization data is very sensitive even if they don't want to share their data with third parties. If you haven't plan migration properly there may chances of leakage or data loss.
- **Security:** In today's era, security is very essential and necessary for proper functioning of your application so while choosing cloud service provided all security concerned should be fixed or checked off.
- **Cost and Time:** Proper planning and management of cloud migration may take more time and it will increase the overall cost at the initial stage.

4.3 MICROSOFT CLOUD SERVICES

- As discussed earlier Cloud Service Providers (CSP) are several companies that offer on-demand cloud computing services like Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS).
- Microsoft is also one of the leading global providers of cloud computing services for businesses of all sizes.

4.3.1 What is Azure?

- The Azure is cloud platform provided by Microsoft.
- Microsoft Azure is a public cloud platform. It has more than 200 products and cloud services covering 18 broad categories.
- All such services are designed:
 - To help users to bring new solutions and to solve today's challenges.
 - To Build, run and manage applications across multiple clouds, on-premises and at the edge, with the tools and frameworks of customers choice.
- Azure integrates the cloud services that you need to develop, test, deploy, and manage your applications, all while taking advantage of the efficiencies of cloud computing.

4.3.2 Microsoft Azure Services

- Azure offers many services which fulfills the requirement of today's digital world including several popular and important broad categories as shown in Fig. 4.2:

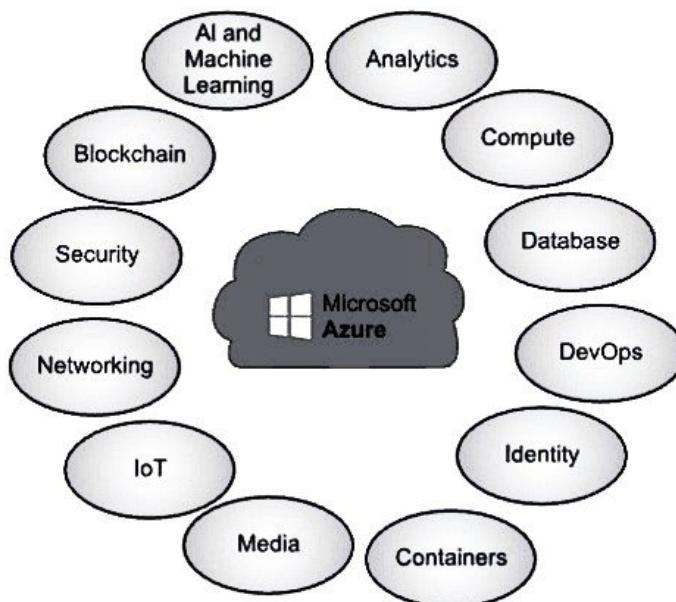


Fig. 4.2: Broad Categories of different services offered by Microsoft Azure

- **Azure AI and ML:**
 - Services under this category are designed for developers and data scientists.
 - Azure AI offers to build and deploy your own AI solutions by considering the decades of scientific research in AI and responsible practices.
 - It provides after access high-quality vision, speech, language, and decision-making AI models through simple API calls.
 - Support to create your own machine learning models with several tools like Jupyter Notebook, Visual Studio Code, and open-source frameworks like TensorFlow and PyTorch etc.
 - It includes Azure bot service, Azure Cognitive Search, Azure Machine Learning, Speech Analytics, Speech to Text, Language Analyzer etc.
- **Analytics:**
 - Services under this category offers comprehensive set of solutions which turn your data into actionable intuitions.
 - It includes Azure Synapse Analytics, Azure Purview, Azure Data factory, HDInsight, Azure Analysis Services etc.
- **Compute:**
 - Services under this category are designed to provide cloud based compute facilities like Virtual Machine, Azure Spring Cloud, App Service etc.
- **Database:**
 - Services under this category are designed to support rapid growth and innovate faster with secure, enterprise-grade and fully managed database services like Azure SQL, Azure CosmosDB, Azure SQL Database, Azure Database for PostgreSQL etc.

- **DevOps:**
 - Services under this category are very helpful to deliver innovation faster with simple and reliable tools.
 - It includes Azure Artifacts, Azure Boards, Azure DevOps, Azure Monitor, Azure Pipelines etc.
- **Development:**
 - Services under this category facilitates development using any language or platform.
 - It includes Azure DevTest Labs, Azure Lab Services, Visual Studio, Visual Studio Code etc.
- **Identity:**
 - Services under this category could be helpful to Manage user identities and access to protect against advanced threats across devices, data, apps, and infrastructure.
 - It includes Azure Active Directory, Azure Information Protection etc.
- **Security:**
 - Services under this category are useful for protection of our enterprise from advanced threats in hybrid cloud workloads.
 - It includes Azure Gateways, Azure DDoS protection, Security center etc.
- **Azure IoT:**
 - Services under this category offers powerful features for IoT applications. It has Simple tools, simple templates, simply open source.
 - The open approach of Azure IoT places simplicity of development and integration at the forefront.
 - These services are used to Connect, monitor and control billions of devices.
- **Containers:**
 - Services under this category are helpful to develop and manage your containerized applications faster with integrated tools.
 - API Apps, Azure Functions, Azure Kubernetes Services, Azure RedHat Open shift, Service fabrics these are the several services under this category.
- **Media:**
 - Services under this category are useful to deliver high-quality video content flexibly on any kind of device and at any time.
 - It includes Azure Media Player, Live streaming, Content Delivery Network etc.
- **Network:**
 - Services under this category are useful to connect cloud and on-premises infrastructure and services.
 - It includes Application Gateway, Azure Bastion, Azure DDoS Protection, Azure DNS, Azure Firewall, Azure Orbital etc.

- **Storage:**
 - Services under this category are helpful for secure, massively scalable cloud storage for your data, applications as well as workloads.
 - It includes Archive storage, Azure Backup, Azure Data lake storage, Azure Data share, Azure files etc.
- **Blockchain:**
 - Services under this category are helpful to build and manage blockchain based applications with a suite of integrated tools.
 - It includes Azure Block Chain Service, Azure Blockchain Workbench, Azure Logic Apps etc.

4.3.3 Application Hosting Options in Azure

- Azure provides user-friendly cloud based computes. Azure offers true serverless hosting where user just needs to write their code.
 - Services offered by Azure that help and support user's application development and hosting requirements.
 - Azure provides three options to host a web application are: Azure Virtual Machines, App Service and Service Fabric.
1. **Azure App Service:**
 - This service makes it easy to extend your web apps to support your mobile clients and publish easily consumed REST APIs.
 - Azure App Service provides authentication by using social providers, traffic-based auto scaling, testing in production, and continuous and container-based deployments.
 - Using this you can make web apps, mobile app back ends, and API apps.
 - App Service has been designed with DevOps in mind.
 - It supports various tools for publishing and continuous integration deployments. These tools include GitHub webhooks, Jenkins, Azure DevOps, TeamCity etc.
 2. **Azure Virtual Machines:**
 - It is an Infrastructure-as-a-Service (IaaS) provider.
 - Azure Virtual Machines supports the arrangement of Windows or Linux VMs to Azure.
 - While using such service users have choice or total control over the configuration of the machine (RAM, Storage etc.).
 - While using Virtual Machines user is responsible for all server software installation, configuration, maintenance, and operating system related stuff.
 3. **Azure Service Fabric:**
 - Azure Service Fabric is a distributed systems platform.

- This platform makes it easy to build, package, deploy, and manage scalable and reliable **micro-services**.
- It also provides inclusive application management capabilities such as: Provisioning, Deploying, Monitoring, Upgrading/patching, Deleting
- Apps, which run on a shared pool of machines, can start small and scale to hundreds or thousands of machines as needed.
- Service fabric supports WebAPI with Open Web Interface for .NET (OWIN) and ASP.NET Core. It provides Software Development Kits for building services on Linux in both .NET Core and Java.

4.4 GOOGLE CLOUD APPLICATIONS

- Google is one of the leading and very popular organizations, which is continuously working to provide and fulfill all aspects of digital world.
- Google offers suite of cloud computing services called as Google Cloud Platform (GCP). It is one of the public cloud computing platforms.
- Google cloud Platform offers services like application development, compute, storage, networking, Big Data, and many more.
- These platforms also run on the same cloud infrastructure that Google uses internally for its end-user products, such as Gmail, Google Drives, YouTube etc.

4.4.1 Important services offered by Google Cloud Platform (GCP)

- Categories of different services provided by Google Cloud Platforms (GCP) are as shown in Fig. 4.3.

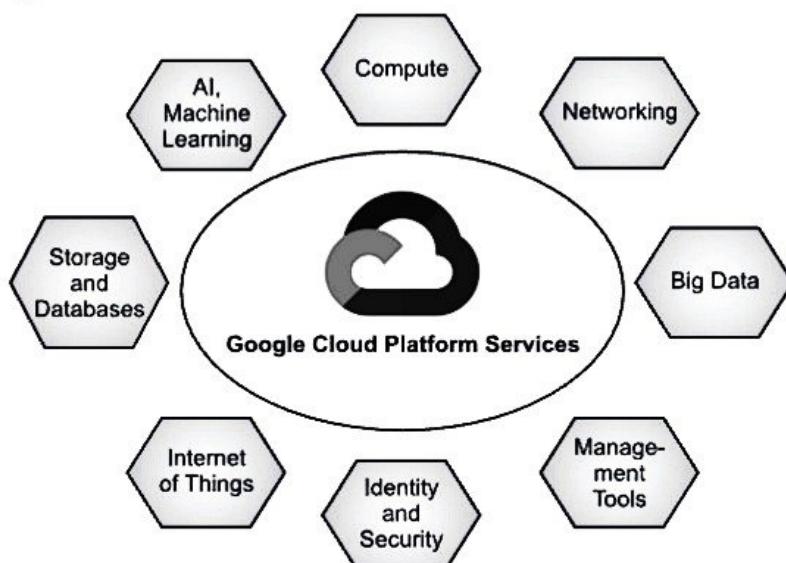


Fig. 4.3: Services Provided by Google Cloud Platform (GCP)

Several services offered by GCP are listed here:

- **Compute Engine:**
 - It is an Infrastructure as a Service (IaaS). GCP offers Secure and customizable compute services.
 - This engine is helpful to create our virtual machines on Google's infrastructure.
- **Google App Engine:**
 - It is Platform as a Service (PaaS).
 - It is a cloud computing platform for developing and hosting web applications in Google managed data centers.
 - It offers the automatically scalable facility means App Engine automatically allocates more resources as per number of requests.
 - It is used to deploy Java, PHP, and many more applications.
- **Kubernetes Engine:**
 - It is cluster management system.
 - It provides a platform for automating deployment, scaling, and operations of application containers across clusters of hosts.
 - It works with docker as well as many container tools.
- **Google Cloud Storage:**
 - It is a kind of storage service offered by Google.
 - It is an online file storage web service for storing and accessing data on a Google Cloud platform (GCP) infrastructure.
 - The service combines the performance and scalability of Google Cloud with advanced security and sharing capabilities.
- **Cloud SQL:**
 - Cloud SQL supports us to create, configure as well as use relational databases that reside in Google Cloud.
 - It does all the things i.e. maintains, manages, and administers our databases so that we can give more focus on applications and services.
- **Cloud Bigtable:**
 - It is a kind of storage service offered by Google.
 - It is NoSQL database service which is highly scalable, fast; fully managed.
 - It is designed for the collecting and retention of data from one TB to hundreds of PB.
- **Google Cloud Datastore:**
 - It is fully managed, schema less, non-relational datastore offered by Google.

- It supports atomic transactions and a rich set of query capabilities. It has auto scale up and down facility based on the load.
- **BigQuery:**
 - It is data analysis service which offered by Google.
 - It is a fully managed that enables businesses to analyze their Big Data. It is highly scalable data storage.
 - It has the capacity to perform ad-hoc queries, and the ability to share data on the web.
- **Google Cloud Dataproc:**
 - A fast, easy-to-use and manage Spark and Hadoop service for distributed data processing.
 - It is used to create Spark or Hadoop clusters, sized for your workloads precisely when you need them.
- **Virtual Private Cloud:**
 - It is networking service provided by Google.
 - Virtual private cloud provides a private network with IP allocation.
 - It also provides routing and network firewall policies to create a protected environment for your deployments.
- **Cloud Load Balancing:**
 - This service is used for distributing workloads across multiple computing resources.
 - This reduces the cost and maximizes the availability of the resources.
 - It is used for efficient utilization of computing resources.
- **Content Delivery Network:**
 - It is also a kind of networking service. It is a geographically distributed network of proxy servers and their data centers.
 - This service aims to provide high availability and high performance by spatially distributing the service relating to end users.
- **Cloud IoT Core:**
 - This service is useful for IoT applications.
 - It allows us to easily and securely connect, manage, and ingest data from devices that are connected to the Internet.
 - It allows us for utilization of other Google cloud services for collecting, processing, analysing, and visualizing IoT data in real time.
- **Cloud IoT Edge:**
 - It is used to bring memory and computing power closer to the location where it is needed.

- **Cloud Machine Learning Engine:**
 - This service allows you to build machine learning models based on mainstream frameworks.
- **Cloud AutoML:**
 - A machine learning product that enables developers to provide their data sets and obtain access to quality trained models by Google's transfer learning and Neural Architecture Search.

4.5 AMAZON CLOUD SERVICES

- Like Google and Microsoft Amazon is also one of the leading cloud service providers with name Amazon Web Service (AWS).
- AWS also offers a broad set of global cloud-based products like compute, storage, databases, analytics, networking, mobile, developer tools, management tools, IoT, security and enterprise applications. All these services provide platforms to the different organizations to move faster with lower IT costs and scale.
- AWS is trusted by the many enterprises and the hottest start-ups to power a wide variety of workloads including: web and mobile applications, game development, data processing and warehousing, storage, archive etc.

4.5.1 Important services offered by Amazon Web Services

- **Amazon EC2:**
 - Amazon Elastic Compute Cloud(Amazon EC2) is one of the IaaS offered by Amazon.
 - It is a web service that provides secure, resizable compute capacity in the cloud.
 - Amazon EC2's simple web service interface allows us to obtain and configure computing capacity easily.
 - It provides complete control to you on your computing resources and lets you run on Amazon's proven computing environment.
 - It gives us choice of processor, storage, networking, operating system, and purchase model.
- **AWS App Runner:**
 - It is a fully managed service that makes it easy for developers to quickly deploy containerized web applications and APIs, at scale and with no prior infrastructure experience required.
 - App Runner support to builds and deploys the web application and load balances traffic with encryption.
 - It scales up or down automatically to meet customers traffic needs.
 - Rather than worrying about infrastructure or scaling, you can concentrate on your applications.

- **Amazon Lightsail:**

- It is also one of the compute service offered by Amazon. It is a Virtual Private Server (VPS).
- It is easy-to-use and offers everything needed to build an application or website.
- It is best suited for new users who are looking to get on the cloud quickly with AWS infrastructure.

- **Amazon Elastic Kubernetes Service:**

- Amazon Elastic Kubernetes Service also called as Amazon EKS.
- It gives us flexibility to start, run, and scale Kubernetes applications in the AWS cloud or on-premises.
- Amazon EKS helps us to provide highly-available and secure clusters and automates key tasks such as patching, node provisioning, and updates.
- Organizations including Intel, Snap, GoDaddy trusted on EKS to run their most sensitive and mission critical applications.
- EKS runs upstream Kubernetes and is certified Kubernetes conformant for a predictable experience.
- We can easily migrate any standard Kubernetes application to EKS without needing to refactor your code.

- **Amazon Aurora:**

- It is one of the Database services offered by Amazon.
- Amazon Aurora is a MySQL and PostgreSQL-compatible relational database built for the cloud.
- It combines the performance and availability of traditional enterprise databases with the simplicity and cost-effectiveness of open source databases.
- It is up to five times faster than standard MySQL databases and three times faster than standard PostgreSQL databases.
- It provides the security, availability, and reliability of commercial databases at $1/10^{\text{th}}$ the cost.
- Amazon Aurora is fully managed by Amazon Relational Database Service (RDS), which automates time-consuming administration tasks like hardware provisioning, database setup, patching, and backups.

- **Amazon DynamoDB:**

- Unlike Amazon Aurora it is NoSQL database service.
- Amazon DynamoDB is a key-value and document database that delivers single-digit millisecond performance at any scale.
- It's a fully managed, multi-region, multi-active, durable database with built-in security, backup and restore, and in-memory caching for internet-scale applications.

- DynamoDB can handle more than 10 trillion requests per day and can support peaks of more than 20 million requests per second.
- **Amazon Quantum Ledger Database (QLDB):**
 - Amazon QLDB is a fully managed ledger database that provides a transparent, immutable, and cryptographically verifiable transaction log owned by a central trusted authority.
 - It can be used to track each and every application data change and maintains a complete and verifiable history of changes over time.
 - Ledgers are typically used to record a history of economic and financial activity in an organization.
 - Many organizations build applications with ledger-like functionality because they want to maintain an accurate history of their applications' data, for example, tracking the history of credits and debits in banking transactions, verifying the data lineage of an insurance claim, or tracing movement of an item in a supply chain network.
 - Ledger applications are often implemented using custom audit tables or audit trails created in relational databases.
 - QLDB is easy to use because it provides developers with a familiar SQL-like API, a flexible document data model, and full support for transactions.
- **AWS IoT Core:**
 - This service is useful for IoT applications.
 - AWS IoT Core used to connect IoT devices to the AWS cloud.
 - AWS IoT Core can support billions of devices and trillions of messages, and can process and route those messages to AWS endpoints and to other devices reliably and securely.
 - With AWS IoT Core, your applications can keep track of and communicate with all your devices, all the time, even when they aren't connected.
- **AWS IoT Analytics:**
 - It is a fully-managed service for refined analytics on massive volumes of IoT data.
 - It is the easiest way to run analytics on IoT data and get insights to make better and more accurate decisions for IoT applications with ML techniques.
 - IoT data is highly unstructured which makes it difficult to analyze with traditional analytics and business intelligence tools that are designed to process structured data.
 - IoT data comes from devices that often record fairly noisy processes (such as temperature, motion, or sound).
 - It helps to analyze data from millions of heterogeneous devices and build fast, responsive IoT applications.

- **AWS IoT Device Management:**
 - It is used to register, organize, monitor, and remotely manage IoT devices at large scale.
 - We can organize our devices, monitor and troubleshoot device functionality, query the state of any IoT device.
 - AWS IoT Device Management is agnostic to device type and OS, so you can manage devices from constrained microcontrollers to connected cars all with the same service.
- **Amazon Virtual Private Cloud:**
 - It allows us to build a logically isolated virtual network in the AWS cloud.
 - As one of AWS's foundational services, Amazon VPC makes it easy to customize your VPC's network configuration.
 - It gives us complete control of our virtual networking environment, including selection of our own IP address range, creation of subnets, and configuration of route tables and network gateways.
- **Amazon API Gateway:**
 - It makes it easy for developers to create, publish, maintain, monitor, and secure APIs at any scale.
 - APIs act as the "front door" for applications to access data, business logic, or functionality from your backend services.
 - Using API Gateway, you can create RESTful APIs and WebSocket APIs that enable real-time two-way communication applications.
 - API Gateway supports containerized and serverless workloads, as well as web applications.
- **AWS Backup:**
 - It is a kind of storage service offered by Amazon which centrally manage and automates backups across AWS services.
 - AWS Backup enables us to centrally deploy data protection policies to configure, manage, and govern our backup activity across our organization's AWS accounts and resources, including Amazon Elastic Compute Cloud (Amazon EC2) instances and other similar amazon services too.

4.6 CLOUD APPLICATIONS

- As discussed in previous sections Cloud Service Providers (CSP) are providing many types of cloud services and now cloud computing has reached nearly about every sector in the form of different applications.
- As it makes sharing and management of resources simpler because of that it is one of the popular fields of computing.

- These properties of cloud computing have made it an active component in many fields.

Several real-world applications of cloud computing are as given below:

- **Backup and Recovery :**
 - Backup and recovery of data is very complicated task in traditional methods; it may cause some time data lost. Because of cloud computing it is now easy for vendors to take care about both of these things.
 - As cloud service providers provide security from their side by storing safe to the data as well as providing a backup facility to the data hence data backup is one of the important applications of cloud computing.
 - CSP also offers numerous data recovery applications for retrieving the lost data.
 - Cloud computing makes it possible to access data from anywhere and anytime.
- **Bigdata Analysis :**
 - Data with high volume, high velocity and high amount of variation are referred as big data so storing and managing that in traditional data management system for an organization is very challenging task.
 - But cloud computing has resolved that problem by allowing the organizations to store their large volume of data in cloud storage without worrying about physical storage.
 - Analyzing the raw data and finding out the knowledge or useful information from it is a big challenge as it requires high-quality tools for data analytics.
 - Cloud computing provides the biggest facility to organizations in terms of storing and analyzing big data.
- **Education:**
 - We learn big lesson from COVID-19 Pandemic which underlines the importance of various cloud platforms.
 - We are now using various cloud based platforms to fulfill the requirement of teaching learning process. G suite is the best example of such Cloud based service.
 - Even though various cloud based video conferencing tools have also proven their importance during this pandemic situation.
- **E-Commerce:**
 - Cloud based e-commerce allows quick response to the emerging opportunities in the market.
 - Cloud based e-commerce offers new ways of doing and expanding business with less money and less time. All kinds of business related data can be managed in cloud environment.

- **Entertainment:**
 - Entertainment is also one of the most important industries, with a significant economic impact.
 - Many people obtain their entertainment via the internet, therefore cloud computing is the ideal platform for reaching out to a wide audience.
 - On-Demand Entertainment is another name for it (ODE).
 - As a result, various types of entertainment stakeholders can reach their target audience by executing a multi-cloud strategy.
- **Internet of Things:**
 - Cloud computing also plays an important role for connecting heterogeneous devices to the internet.
 - Various cloud based platforms give backbone support to the IoT applications.
 - SenseIoT, REDnode, Carriots etc. are several examples of such platforms.
- **Software Development:**
 - Cloud computing offers a simple approach for software development as well as testing even if deployment by using their IT resources with low cost.
 - Cloud Computing provides scalable and flexible services for product development, testing, and deployment.
 - Examples: Google App Engine, Heroku, AWS Lambda etc.

Summary

- The process of moving applications from local to the cloud environments is referred to as Migration.
- Assessment, Isolation, Mapping, Re-architect, Augment, Validate or test and Optimization are the seven steps in the Migration Process.
- The Azure is cloud platform provided by Microsoft.
- Azure integrates the cloud services that you need to develop, test, deploy, and manage your applications, all while taking advantage of the efficiencies of cloud computing.
- Google offers suite of cloud computing services called as Google Cloud Platform (GCP).
- Google cloud Platform offers services like application development, compute, storage, networking, Big Data, and many more.
- Like Google and Microsoft Amazon is also one of the leading Cloud service Provider with name Amazon Web Service (AWS).
- Cloud services and now cloud computing is reached near about every sector in the form of different applications.

Check Your Understanding

1. _____ is the first step of the iterative seven-step model migration process.

(a) Assessment	(b) Mapping
(c) Validation	(d) Augment
2. Azure DDoS is the service offered by _____.

(a) Google	(b) Microsoft
(c) Amazon	(d) Intel
3. Google offers a suite of cloud computing services called as _____.

(a) Google Web Service	(b) Google Cloud Platform
(c) Google Docs	(d) Google Drive
4. _____ is a "serverless" style offering that lets you write just the code you need.

(a) Azure App Engine	(b) Azure Virtual Machine
(c) Azure Functions	(d) Azure Fabric service
5. Azure Virtual Machine is a _____.

(a) IaaS	(b) SaaS
(c) PaaS	(d) NaaS
6. Amazon EC2 is _____.

(a) IaaS	(b) SaaS
(c) PaaS	(d) NaaS
7. The process of moving applications from local to the cloud environments is referred to as _____.

(a) Shifting	(b) Translation
(c) Transaction	(d) Migration
8. Amazon DynamoDB is _____ Database Service

(a) MySQL	(b) PostgreSQL
(c) NoSQL	(d) SQL

Answers

- | | | | | | | | |
|--------|--------|--------|--------|--------|--------|--------|--------|
| 1. (a) | 2. (b) | 3. (b) | 4. (c) | 5. (a) | 6. (a) | 7. (d) | 8. (c) |
|--------|--------|--------|--------|--------|--------|--------|--------|

Practice Questions

Q.I Answer the following questions in short.

1. Write note on Azure AI.
2. What is the role of Re-architect step in the 7 step model of migration Process?
3. Write note on Azure App Service.
4. What is the risk in Cloud Migration?

5. What is GCP?
6. Write a note on Amazon Aurora.

Q.II Answer the following questions.

1. Describe the seven steps Model of cloud Migration Process.
2. What are the different cloud services provided by Microsoft Azure under AI and Machine Learning Category?
3. What is Cloud Migration? Give its benefits and risk?
4. Describe the different broad categories of services offered by Microsoft Azure.
5. Give the impact of Cloud services on Education System.
6. What are the different applications of Cloud Services?
7. Write a note on AWS IoT Device Management.
8. Write a note on Amazon Quantum Ledger Database (QLDB).
9. Describe the role of Cloud for Backup and Recovery.

Q.III Define the terms.

1. Cloud migration
2. Azure
3. EC2
4. AWS

❖❖❖

5...

Emerging Trends in Cloud Computing

Learning Objectives ...

- To know about Emerging trends in Cloud Computing.
- To learn about Multi Cloud and Omni Cloud.
- To get familiar with Integrated Blockchain technology, Kubernetes, Cloud AI and Intelligent SaaS.

5.1 INTRODUCTION

- In this chapter we are covering the latest trends in the cloud computing and how cloud computing is growing in different dimensions to expand its coverage and to fulfill the market needs.
- Many organizations are providing solutions to the challenges and risks while using cloud services.
- Here, we will discuss about future technologies and advancement in the cloud computing and also focus on the concepts of Multi-cloud, Omni-cloud then importance of block chain technology, Cloud AI, Intelligent SaaS etc.

5.2 MULTI-CLOUD VS OMNI-CLOUD

5.2.1 What is Multi-Cloud?

- A multi-cloud environment is one in which an organization employs multiple cloud platforms (at least two or more public clouds) to supply different applications and services.
- However, to fulfill the enterprise's end goals, a multi-cloud might be made up of public, private, and edge clouds.
- In other words, it blends on-premise operations with services and applications hosted by a variety of public cloud providers, allowing businesses to reap the benefits of each platform while minimizing the drawbacks.

(5.1)

- Fig. 5.1 shows an example where two public clouds are adopted by an enterprise application.

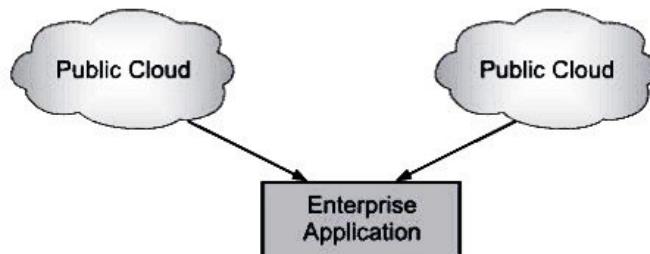


Fig. 5.1: Multi-cloud Environment

When Multi-cloud would be adopted?

- To avoid data loss or downtime in the cloud as a result of any component failure.
- To avoid vendor lock-in.
- High availability of the services.
- Data sovereignty allows enterprises to locate computational resources as close as possible to end users, resulting in best performance and minimal delay.
- To achieve larger business as well as technical goals, such as using more cost-competitive cloud services or leveraging the speed, capacity, or features offered by a specific cloud service provider in a specific location.

Challenges while using Multi-cloud Environment:

- Lack of Expertise (Talent Management):**
 - Specialists in the cloud are in high demand.
 - Cloud architects and engineers with a single cloud provider's experience are hard to come by.
 - Hiring professionals who are knowledgeable about multiple clouds is nearly difficult.
 - In a multi-cloud environment experienced specialists are needed who can create apps for several cloud platforms.
- High cost:**
 - While having multiple providers estimating costs and consolidating them becomes increasingly difficult.
 - Because each cloud provider charges differently for each service.
 - Requirement of skilled staff having expertise in different services also increases the cost.
- Governance and Resource Management:**
 - Every cloud hosting environment has its own architecture, which is designed and created in accordance with it.

- It's inevitable for mismanagement to occur when several providers provide different services.
- Multi-cloud environments will not be handled properly due to a lack of skills and competence for managing numerous clouds, this might become a serious challenge for enterprises.

4. Security:

- It is not a problem if you deal with just one Cloud service provider to manage data security.
- Storing your data on several clouds adds complexity, making it more difficult to protect and avoid data loss.
- Multi-cloud environment can be far more difficult to secure than a single cloud.
- Many aspects need to be considered, including: Encryption keys, Resource policies, Access control management, SSL (Secure Security Layer)/TLS (Transport Layer Security) encryption etc.

5.2.2 What is Omni-Cloud?

- There are many challenges imposed by multi-cloud because of multiple service providers and there varying infrastructure.
- Omni-cloud provides the solution to several challenges in multi-cloud environment.
- Omni-clouds offer world-class connectivity and enable multiple platforms to streamline their data and integrate the data more effectively as compared to multi-cloud.
- When obstacles between different platforms shrink, then, in that case, any multi-cloud needs to be converted into an omni-cloud system.

Benefits of Omni-cloud:

1. Secured and Scalable:

- The majority of omni-cloud Systems on the market include high-quality, well-invested firewalls and other security features.
- Many E-commerce enterprises today have millions of people purchasing online, resulting in tremendous visitor volumes. Scalability is essential in such a situation.
- Omni-cloud Systems provides a cost-effective alternative to purchasing extra servers and databases on a regular basis.

2. Economically Feasible:

- It has lower operational costs.
- This allows organizations to spend the money saved on other development projects.

3. Easy for Analytics:

- When data is hosted across various cloud infrastructures, data analysis becomes very difficult.
- It can easily turn into a time-consuming and exhausting activity.
- Omni-cloud improves all of these issues by allowing for seamless data synchronization.

5.2.3 Multi-Cloud becomes Omni-Cloud?

- Multi-Cloud appeared to be the best option. It was affordable, scalable, and adaptable.
- On the other hand, as the business's needs evolved and there needs are changing, it became necessary for the various clouds to interact.
- Every cloud now has its own infrastructure and hosting environment.
- Coordination was fragmented when multiple cloud architectures were joined.
- When corporations were compelled to withdraw from the multi-cloud due to a lack of cooperation, everything came to a head.
- As a result, the omni-cloud was born, allowing all platforms to streamline and unify their data.

5.3 INTEGRATED BLOCKCHAIN TECHNOLOGY**5.3.1 What is Blockchain Technology?**

- The introduction of Bitcoin coincided with the invention of Blockchain technology.
- Bitcoin is a type of digital currency created in 2008 by Satoshi Nakamoto."
- Blockchain is a distributed ledger that records tamper-evident data in the form of a chain without a central authority.
- Nodes are the participants or devices in the blockchain technology.
- The blockchain technology creates a decentralized network in which all network nodes actively participate in validating and verifying data.
- Cryptography will be used to encrypt the data that will be stored in the blockchain.
- Every block has an encrypted hash, a timestamp, and the hash of the preceding block in the chain to which it will connect.
- The data on the blockchain cannot be tampered.
- Blockchain secures data, and users who participate in the network will be verified, removing the data's privacy concern, which the block will connect.
- Blockchain technology is the way of the future for industries seeking better security and privacy.
- We can solve the data's privacy and security problems by integrating blockchain technology to support cloud computing growth.
- It boosts data security, service availability, and cloud data management.

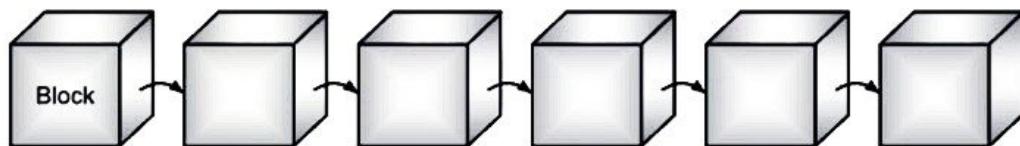


Fig. 5.2: Blockchain

5.3.2 Characteristics of Blockchain Technology

1. Decentralization:

- Without the intervention of a third party, the blockchain is made up of peer-to-peer blocks.
- This eliminates the requirement for a centralised server to store and update numerous systems on the blockchain.
- All participants or nodes, actively participate in transactions with a decentralised server, reducing the server's workload.

2. Persistency:

- In the blockchain, all transactions are verified, and honest miners save the data.
- Rolling back or removing transactions is difficult if they are listed on the list.
- Furthermore, other miners validate these blocks, ensuring that they cannot be tampered with.

3. Autonomous:

- We can publish the signed nodes and examine them to see if other nodes in the decentralised network accept them because the blockchain network is not controlled by a single entity.
- The consensus basis was formed by every other node in the network approving a node, assuring that data would be sent safely in the blockchain.

4. Auditability:

- All transactions in the blockchain will be digitally signed by the sender, storing the block with the date and allowing users to easily monitor and verify transaction details.

5. Immutability:

- The transactions are forever recorded on the blockchain.
- The data in the blocks is unchangeable.
- If someone tries to change the data, it will be quickly detected because the data in the blocks is linked by the hash key, and any changes to the data will invalidate the next connected blocks.

6. Transparency:

- Blockchain is a decentralised system that allows all participants to publish their records and access the data of the nodes.
- The system stores and preserves transaction data information in an open distributed ledger using blockchain technology.
- This data is accessible and trustworthy, allowing all nodes in the same network to access it.

7. Traceability:

- Hashing methods are used to encrypt the data stored in blockchain blocks. A hash key will be used to identify each block.
- Each block in the network is linked using the hash keys of the previous blocks.
- As a result, in the blockchain network, tracking a block using its hash key is simple.

5.3.3 Types of Blockchain

Following are the three types of Blockchain:

1. Public (Permissionless) Blockchain:

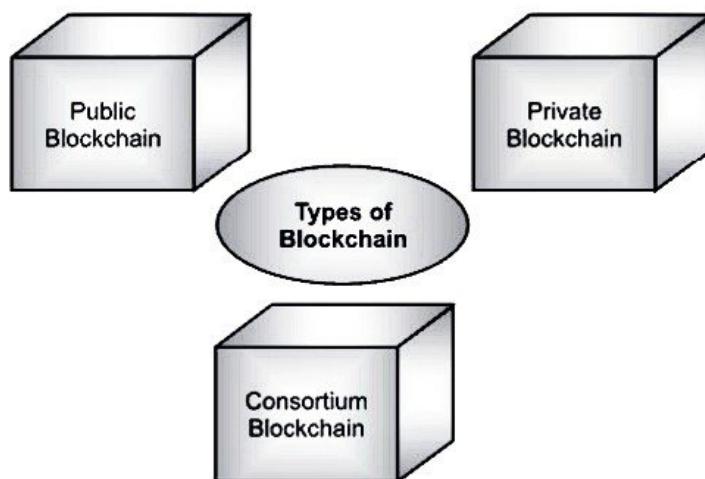
- A public blockchain is a decentralized, open ledger in which any node can enter the network and can engage in the processing, storage, and validation of the transaction data through a consensus mechanism.

2. Private (Permissioned) Blockchain:

- The private blockchain has a limited number of participants, and no one can join the network quickly.
- It's a sort of centralised blockchain with access regulated by a central authority.
- The data read authorization on the private blockchain is only made available to the public on a case-by-case basis.
- The term "private blockchain" refers to a type of blockchain that is only used by a few companies or small industries.

3. Consortium Blockchain:

- The consortium blockchain is a decentralised chain with some centralization.
- The pre-selected node will have the authority to select the service type ahead of time.
- The remaining nodes may have access to blockchain transactions, but they are excluded from the consensus process.

**Fig. 5.3: Types of Blockchain**

5.4 KUBERNETES

- Kubernetes originates from Greek word. It means “helmsman” or “pilot”.
- It is abbreviated as K8s (it means that eight letters between K and S) or Kube.
- It is portable and extensible, open source platform for management of containerized workloads and services that accelerates both declarative configuration and automation.
- It is Container Orchestration Solution. It has ecosystem which is very large and promptly rising.
- Kubernetes services, support, and tools are widely available.
- It supports many services provided by almost all public cloud service providers.
- Kubernetes are used to keep track of container applications deployed on the cloud.
- Kubernetes can control resource allocation and traffic management for cloud applications and micro services.

Features of Orchestration offered by Kubernetes:

- High availability or no downtime.
- Scalability or high performance.
- Disaster recovery because of backup restoration.

5.4.1 Architecture of Kubernetes

- Kubernetes is works on client-server architecture.
- Architecture of Kubernetes consist of following two main components:
 1. Master
 2. Node (Slave)
- Architecture of Kubernetes is as shown in Fig. 5.4:

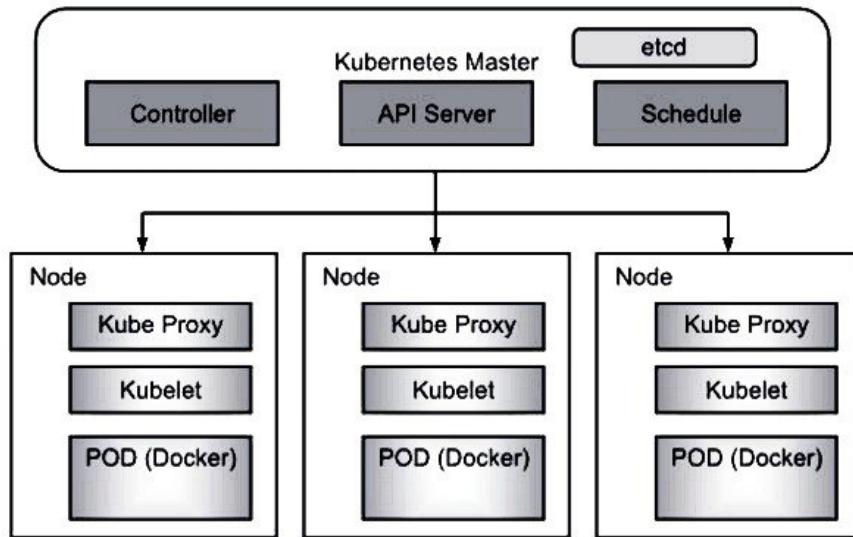


Fig. 5.4: Architecture of Kubernetes

1. Kubernetes Master:

- All administrative tasks are managed by master. It is responsible for managing the Kubernetes cluster. There may be one or more master nodes in the cluster.
- Following are the important components of Kubernetes Master:
 - **etcd:**
 - etcd is a distributed key-value store which is responsible for storing the cluster state.
 - It also has all the information about configuration which is used by each of the nodes in the cluster.
 - It can be accessed by Kubernetes API server.
 - **API Server:**
 - Performs all the administrative tasks through the API server within the master node.
 - It provides all the operation on cluster using the Application Programming Interface.
 - It gives interface to different tools and libraries to communicate with it.
 - Kubeconfig is a package along with the server side tools that can be used for communication.
 - **Controller Manager:**
 - It is responsible for most of the collectors that regulate the state of cluster and performs a task.
 - It is like a daemon which runs in non-terminating loop and is liable for gathering and sending data to API server.

- It works toward getting the shared state of the cluster and then makes changes to bring the current status of the server to the desired state.
 - The key controllers are replication controller, endpoint controller, namespace controller, and service account controller.
 - The controller manager runs different kinds of controllers to handle nodes, endpoints, etc.
- **Scheduler:**
 - This is very important components of Kubernetes master.
 - It is responsible for distributing the workload.
 - It is responsible for tracking utilization of working load on cluster nodes and then placing the workload on which resources are available and accept the workload.
 - The scheduler is responsible for workload utilization and allocating pod to new node.
- 2. Node (Slave) Components:**
- These are the key components of Node server which are necessary to communicate with Kubernetes Master. Slave nodes are controlled by Master. These are the physical or virtual servers which run the applications.
 - Pods are scheduled on the slave nodes which are nothing but the collections of container. It is also called as Worker Node.
 - Following are the important components of Slave Node:
 - **Docker (Container Runtime):**
 - Docker is a platform which uses containers as a container runtime.
 - Container runtimes are used to run and manage the lifecycle of containers.
 - **Kubelet:**
 - It is a communication agent that runs on slave nodes and connects with the master node.
 - It obtains the POD specifications via the API server.
 - It executes the containers connected with the POD, and guarantees that the containers described in those PODs are up and running.
 - **Kube Proxy:**
 - As the network proxy, Kube-proxy runs on each slave node.
 - For each service point creation or deletion, it listens to the API server.
 - Kube-proxy creates routes for each service point so that it can communicate with it.

5.5 CLOUD AI

- Artificial Intelligence (AI) is already here, taking over many tasks that were formerly reserved for humans.
- In reality, we use artificial intelligence on a daily basis when we speak with an automated phone system, ask for directions on our smartphones, or receive real-time traffic alerts on our GPS.
- Artificial Intelligence (AI) and cloud computing are combined in the AI cloud, a notion that is only now being adopted by businesses.
- It is being driven by two factors: AI tools and software giving new, greater value to cloud computing, which is no longer only a cost-effective alternative for data storage and computation but is also playing a key role in AI adoption.
- An AI cloud is a shared infrastructure for AI use cases, that can serve a large number of projects and AI workloads at the same time on cloud infrastructure.
- The AI cloud combines AI hardware and software (including open source) to deliver AI software-as-a-service on hybrid cloud infrastructure, allowing businesses to use AI and exploit its capabilities.
- Running AI algorithms requires a large amount of processing power, making it prohibitive for many businesses.
- However, the recent availability of AI software-as-a-service, similar to software-as-a-service or infrastructure-as-a-service, has removed this barrier.

What is AI cloud computing?

- AI cloud computing combines artificial intelligence's machine learning capabilities with cloud based computing environments to enable intuitive, linked experiences.
- Google Assistance, Siri, Amazon Alexa, and Google Home are examples of digital assistants that combine a smooth flow of artificial intelligence technology and cloud based computing resources to allow users to make purchases, manage a smart home, and many more.
- Huge advances in AI, combined with a well-established cloud computing environment are paving the way for unprecedented levels of efficiency, flexibility, and strategic insight.

Impact of AI on Cloud:

- On existing cloud computing platforms, artificial intelligence techniques are being deployed to deliver extra value.
- To give end-users more functionality, SaaS companies are incorporating AI technologies into larger software packages.
- Salesforce is a prominent customer relationship management platform, just added Einstein, a tool that allows you to capture customer data.

- Einstein assists organizations in identifying trends in customer interactions and providing actionable insights to improve future interactions. Such as advising users on which means of communication a specific client likes or giving recommendations to help prospects advance their relationship.
- Customers can now turn data into meaningful insights that they may use to boost sales with Einstein tool new feature.

Several Benefits of Cloud AI:**1. Improved Costs:**

- To generate meaningful results from advanced artificial intelligence systems, a lot of processing power is required.
- Until recently, most businesses could not afford to implement AI technology in any meaningful way. The integration of AI on cloud computing platforms has changed the scenario.
- Through AI-as-a-Service (AIaaS) platforms, even the tiniest enterprises may now benefit from the power of AI technologies.
- AlaaS solutions like SaaS platforms charge a monthly subscription for AI technology and store the processing capacity in the cloud, allowing it to be deployed anywhere.
- This saves money up front and may be scaled if your company's demands change.

2. Increased Productivity:

- Artificial intelligence is being utilised in IT infrastructure to streamline workloads and automate repetitive activities, resulting in increased productivity.
- Cloud services that rely on AI tools to manage, monitor, and even correct systems without human intervention are likely to emerge shortly.
- In addition to automating fundamental procedures, AI will play a key role.
- Experts believe that, as AI's analytical capabilities improve, systems will be able to perform regular operations fully on their own, freeing up IT professionals to focus on strategic duties that add value, improve service, and raise the bottom line.

3. Taking Advantage of Big Data

- While we've all heard the term "Big Data" before, our capacity to analyse and interpret it has lagged behind our ability to acquire it.
- Deep learning algorithms are absorbing massive volumes of data thanks to AI technology.
- They get stronger at spotting patterns, generating predictions, and automating complexity as they ingest more data.
- The addition of AI to cloud computing infrastructure means additional processing capability for Big Data analytics, which might someday simplify delivery services, anticipate diseases, and improve customer satisfaction.

5.6 INTELLIGENT SAAS

- Intelligent SaaS products can automate processes and handle all of the tasks we don't want to perform, while also having the potential to become intelligent in the future and generate intriguing data network effects.
- Software and data were only available "on-premise" prior to the SaaS boom. Then came SaaS, which shifted everything to the cloud, enhancing productivity and collaboration by making everything digital and easily available. Intelligent SaaS is the next step in this journey.
- Now that data is on the cloud, companies can start leveraging it and using AI/machine learning to produce a more improvement.
- Intelligent SaaS are services that are using AI components such as Machine Learning (ML), Natural Language Processing (NLP), data analytics, deep learning, robots, general intelligence, expert systems, and so on.
- These services can use historical and real-time data to assist critical user decisions because of the AI-powered algorithm.
- These services can participate in continuous learning due to the clever integration and utilisation of predictive and prescriptive analytics, customer data, and product insights, resulting in the following benefits.
 - Provide users with super-rich and custom-made experiences by providing forecasts and judgments.
 - Provide useful solutions based on users' interactions with brands, people, and machines in the past.
 - Provide personalized and contextual material to keep people engaged.
 - Analyze different data sources to provide useful insights and assist in the automation of simple everyday chores without requiring special knowledge.
- Digital voice assistants from Amazon, Apple, and Google are excellent instances of intelligent apps that mix natural language generation, processing, and machine learning.
- These digital voice assistants have made our lives much easier and more convenient by providing weather and traffic updates, adjusting a smart LED, scheduling meetings, and making your times more enjoyable by cracking jokes and playing music.
- Microsoft has created an AI programme called seeing AI. It's a vision impaired person's talking camera application.
- The software uses the cameras on smartphones to help the blind and low-vision communities throughout the world learn about their environment.
- Its computer vision tells the storey of the visible world by reading brief texts and documents and characterizing a person in real time. It is beneficial to blind people.

5.7 KUBERNETES SUPREMACY

- Kubernetes was first launched in 2015, and it quickly became the industry standard for container orchestration.
- Several reason behind the supremacy of Kubernetes are:
 - Kubernetes is an open source system for deploying, scaling, and managing containerized applications.
 - It takes care of scheduling containers into a computing cluster and managing workloads to ensure they execute as intended by the user.
 - It is designed by Google.
 - Kubernetes integrates software development and operations together by design, rather than bolting them on as an afterthought.
 - The switch from infrastructure as code to infrastructure as data specifically, as YAML (Yet Another Markup Language or YAML isn't markup language) has been one of the most significant changes with Kubernetes.
 - PODs, Configurations, Deployments, Volumes, and other Kubernetes resources can all be defined in a single YAML file.
 - This scenario allows DevOps or site reliability engineers to completely define their workloads without having to write code in Python, Ruby, or Javascript.
- **Kubernetes is extremely Extensible:** There are set of existing resources includes PODs, Deployments, StatefulSets, Secrets, ConfigMaps, and so on. On the other hand, users and developers can use custom resource definitions to add extra resources.
- **Innovation:** Kubernetes has had major releases every three or four months over the past few years, resulting in three or four major releases every year.
- **Community:** Kubernetes' popularity is bolstered by its thriving community: The Cloud Native Foundation. As the project progresses, there are a variety of community SIGs (Special Interest Groups) that focus on various aspects of Kubernetes. They are always adding new features and improving the product.

5.8 CONTAINERIZATION BY INDUSTRY GIANTS

5.8.1 What is Containerization?

- As an alternative to virtualization, containerization has become a key trend in software development.
- A container is a standard software unit that encapsulates code and all of its dependencies so that the program can be moved from one computing environment to another fast and reliably.
- The technology is rapidly maturing, resulting in tangible benefits for developers, operations teams, and entire software infrastructure.

- Containerization makes it possible for developers to construct and deploy apps more quickly and securely.
- Traditional methods need code to be written in a certain computing environment, which sometimes results in bugs and errors when transferred to different platforms (for example: Windows to Linux or vice versa). Containerization solves this problem by combining the application code with all of the necessary configuration files, libraries, and dependencies for it to run.
- Single bundle of software, or "container," is separated from the host operating system, allowing it to stand independently and become portable, allowing it to run without problems on any platform or cloud.
- Docker is a well-known runtime environment for developing and deploying software within containers.
- Kubernetes and other orchestration tools make it simple to automate and scale container-based workloads in production environments.

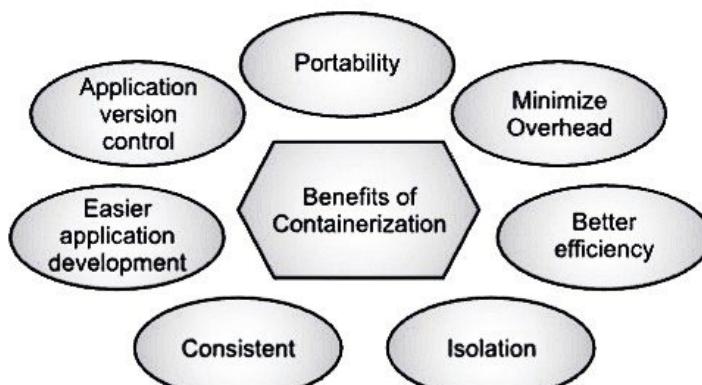
Benefits of Containerization:

Fig. 5.5: Benefits of Containerization

1. **Portability:** Containerized applications may be readily deployed to a variety of operating systems and hardware platforms.
2. **Minimize Overhead:** Because they don't include operating system images, containers utilise fewer system resources than conventional or hardware virtual machine environments.
3. **Better efficiency:** Containers make it easier, faster to deploy, patch, and scaled the application.
4. **Isolation:** Containerized apps are "isolated" in the sense that they don't include a copy of the operating system.
5. **Consistent:** Regardless matter where programs in containers are deployed, it will run in the same way.

6. **Easier application development:** Containers help agile and DevOps efforts to speed up development, testing, and deployment cycles.
7. **Application Version Control:** Users can view the current version of the application code as well as its dependencies using containers in cloud computing. Users may simply hold and track container editions, search for variations between editions, and roll back to prior versions if necessary.

5.8.2 Industry Giants supporting Containerization

- Many services offer containerization, several are listed over here:

1. Docker:

- Docker, an open source container system based on runC, is the most extensively used platform.
- Docker images are more adaptable than some of its competitors since they run on a variety of as a service platforms.
- Docker delivers an isolation technique that allows you to more efficiently augment container resources.

2. CoreOS (rkt):

- CoreOS'rkt pronounced as CoreOS rocket. It is one of the Docker's main competitor.
- It is a low-level framework that employs systems to build core applications.
- It's built to be the container engine powering Google Kubernetes.

3. Google Kubernetes (Cloud Run, GKE & GCE):

- Google Kubernetes has its own container engine, rkt, but it also serves as a community for users to run other popular engines.
- It's an open source host environment for creating and sharing application libraries.
- Kubernetes is a great portable alternative because it provides a fully functional cloud server that can be accessed from any location.

4. Cloud Foundry:

- Cloud Foundry is a cloud based platform for designing, testing, and deploying portable applications.
- Cloud Foundry's Garden is an open source platform that includes containerization as part of its Platform-as-a-Service (PaaS). The container engine is Garden.

5. Amazon AWS:

- AWS provides customers with Backend-as-a-Service (BaaS), which includes a Containers-as-a-Service (CaaS) service.

- o It's also a popular choice for those wishing to deploy Docker images. AWS also provides portability of cloud computing.

Summary

- A multi-cloud environment is one in which an organization employs multiple cloud platforms (at least two or more public clouds) to supply different applications and services.
- Omni-cloud provides the solution to several challenges in multi-cloud environment.
- Kubernetes is portable and extensible, open source platform for management of containerized workloads and services that accelerates both declarative configuration and automation.
- Kubernetes is worked on Client Server Architecture.
- Blockchain is a distributed ledger that records tamper-evident data in the form of a chain without a central authority.
- We can solve the data's privacy and security problems by integrating blockchain technology to support cloud computing growth.
- Artificial Intelligence (AI) and cloud computing are combined in the AI cloud, a notion that is only now being adopted by businesses.
- Running AI algorithms requires a substantial amount of processing power, making it prohibitive for many businesses.
- Intelligent SaaS products can automate processes and handle all of the tasks we don't want to perform, while also having the potential to become intelligent in the future and generate intriguing data network effects.
- Supremacy of Kubernetes: Kubernetes is extremely extensible, which engineers adore. Existing resources include PODs, Deployments, StatefulSets, Secrets, ConfigMaps, and so on.

Check Your Understanding

1. ____ is a platform which uses containers as a container runtime.
(a) Kube proxy (b) POD
(c) Docker (d) Kunbnet
2. ____ will be used to encrypt the data that will be stored in the blockchain.
(a) Steganography (b) Cryptography
(c) Stereography (d) Crypto currency
3. ____ is the way of the future for industries seeking better security and privacy.
(a) Cloud Computing (b) Cloud AI
(c) Blockchain technology (d) Omni-cloud

4. ____ Clouds offer world-class connectivity and enables multiple platforms to streamline their data and integrate the data more effectively as compared to multi-cloud.
 (a) Google (b) Amazon
 (c) Omni (d) AI
5. ____ images are more adaptable than some of its competitors since they run on a variety of as a service platforms.
 (a) Docker (b) CoreOS
 (c) Cloud Foundry (d) Amazon AWS
6. As an alternative to ____, containerization has become a key trend in software development.
 (a) Virtualization (b) Web Server
 (c) Physical Machine (d) API
7. Cloud Foundry's ____ is an open source platform that includes containerization as part of its Platform-as-a-Service (PaaS).
 (a) API (b) Utilities
 (c) Garden (d) Platform
8. ____ is already here, taking over many tasks that were formerly reserved for humans.
 (a) Cloud Computing (b) Artificial intelligence (AI)
 (c) Data Science (d) Blockchain Technology
9. PODs, Configurations, Deployments, Volumes, and other Kubernetes resources can all be defined in a single ____.
 (a) HTML file (b) XML file
 (c) YAML file (d) CSS file
10. Kubernetes is working on ____ architecture.
 (a) Request response (b) Host- Network
 (c) Private public (d) Client Server

Answers

1. (a)	2. (b)	3. (c)	4. (c)	5. (a)	6. (a)	7. (c)	8. (b)	9. (c)	10. (d)
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Practice Questions

Q.I Answer the following questions in short.

1. What is role of Kubeproxy in slave node?
2. Write a note on CoreOS(rkt)
3. Why multi-cloud adopted by enterprises?
4. What is etcd in Kubernetes?

5. What are the Benefits of Intelligent SaaS?
6. Write a note on Supremacy of Kubernetes.

Q.II Answer the following questions.

1. What are the different challenges imposed by Multi-cloud Environment?
2. Describe the architecture of Kubernetes.
3. Describe blockchain Technology.
4. What is containerization? What are its benefits?
5. Why multi-cloud becomes omni-cloud?
6. Give the characteristics of the Blockchain Technology.

Q.III Define the terms.

1. Multi-cloud
2. Omni-cloud
3. Kubernetes
4. Container
5. Docker



6...

Security in the Cloud

Learning Objectives ...

- To know about Cloud Security Challenges and Risks.
- To know about Risk Management – Security Monitoring.
- To get familiar with Software-as-a-Service Security.
- To understand the concept of security Governance.
- To learn Security Architecture Design.

6.1 INTRODUCTION

- While using any communication medium data security is very important.
- Authentication, Authorization, Integrity, Availability and Confidentiality are the key aspects of security.
- As we know that cloud computing is based on networks, so there are more chances of security threats.
- While choosing a cloud service provider, it is necessary to check that what level of security it offers? and what kind of security mechanism implemented.
- Because of public network (Internet) and third party involvement, security is major factor of risk.
- There are many cloud service providers in the market to assure the different levels of security.
- In this chapter, we will discuss different aspects of cloud security.

6.2 SECURITY OVERVIEW

- Cloud computing security comprises of different policies, controls, actions (procedures) and technologies which work together to keep secure cloud-based systems, data as well as infrastructure.

- Cloud security is a shared responsibility between the cloud service provider and the customer.
- To understand more about cloud security, it is necessary to know about the Shared Responsibility Model of cloud computing.
- The Shared Responsibility Model is shown in the Fig. 6.1.

On Premises		Shared Responsibility Model in Cloud Computing		
On Premises		IaaS (Infrastructure as a Service)	PaaS (Platform as a Service)	SaaS (Software as a Service)
Applications	Applications	Applications	Applications	Applications
Data	Data	Data	Data	Data
Runtime	Runtime	Runtime	Runtime	Runtime
Middleware	Middleware	Middleware	Middleware	Middleware
O/S	O/S	O/S	O/S	O/S
Virtualization	Virtualization	Virtualization	Virtualization	Virtualization
Server	Server	Server	Server	Server
Storage	Storage	Storage	Storage	Storage
Networking	Networking	Networking	Networking	Networking
		Cloud Service Providers Responsibility		
		Users Responsibility		

Fig. 6.1: Shared Responsibility Model

- Security measures are designed to protect cloud data and to support regulatory obedience.
- Proper security measures protect user's privacy and setup authentication rules for individual users and devices.
- Because of the cloud's shared resource nature, identity management, privacy, and access control are all areas of concern for cloud security.
- Implementation of cloud security processes should be a combined responsibility between the user and service provider.
- As we know, there are three models offered by cloud: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS). Each of these models has its own security issues. Each of these service models defines the boundary between the responsibilities of the service provider and the user.

- The **CSA (Cloud Security Alliance)** stack model establishes the boundaries between each service model and illustrates how different functional units are related to one another.

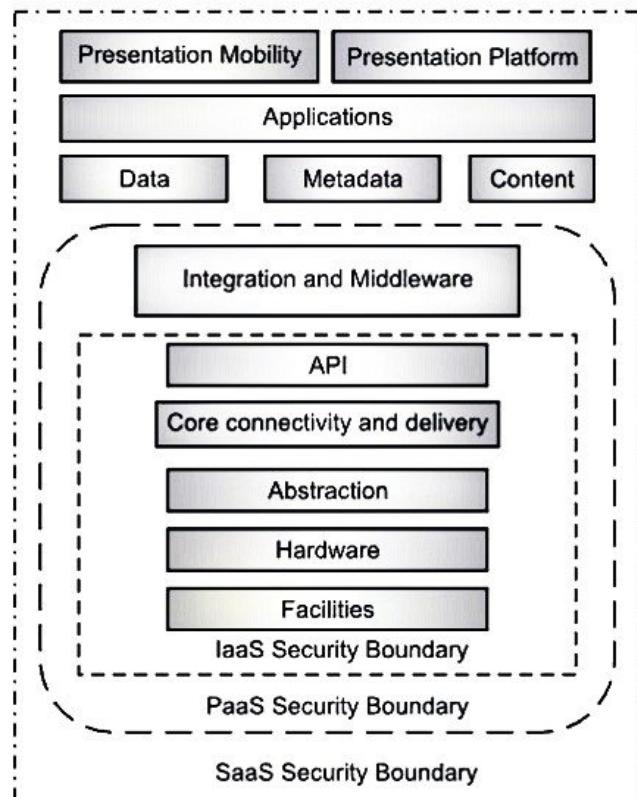


Fig. 6.2: CSA Stack Model

Important aspects of CSA Model are:

- IaaS is basic level of service to PaaS and SaaS.
- Moving from IaaS to SaaS, each of the services inherits capabilities and security concerns of the lower model.
- IaaS offers the infrastructure, PaaS offers platform or development environment, and SaaS provides the working environment.
- IaaS has the smallest level of integrated functionalities and integrated security while SaaS has the most.
- These models describe the clear boundaries between cloud service provider's responsibilities and the customer's responsibilities.
- Any security mechanism below the security boundary must be built into the system and should be maintained by the customer.

6.3 CLOUD SECURITY CHALLENGES AND RISKS

- It's important to know about the challenges organizations have to face after cloud migration. Many organizations are now migrating some part of their IT infrastructure to the public clouds.
- Implementing proper security architecture to survive cyber-attacks is one of the most difficult tasks during this transformation.
- Recently the CSA (Cloud Security Alliance) reported the major cloud challenges in its report "Top Threats to Cloud Computing: Egregious Eleven." These challenges are:
 1. **Data Breaches:**
 - A data breach is a security occurrence in which information is accessed without authorization.
 - Data breaches can effect on businesses and consumers in a variety of ways.
 - It is very harmful and expensive that can damage lives and reputations and take time to repair.
 2. **Misconfiguration and Inadequate Change Control:**
 - This is a common challenge in cloud environment.
 - It includes the grant of excessive permissions or default credentials that haven't changed, it happens while computing assets and access are set up incorrectly.
 - Misconfiguration of cloud resources is a very common cause of data breaches and it can result in deletion or modification of resources and service disruptions.
 - Traditional change control procedures for correct configuration are exceedingly problematic in the cloud due to its dynamic nature.
 3. **Lack of Cloud Security Architecture and Strategy:**
 - When businesses assume that cloud migration is just a matter of "lifting and shifting" their existing IT stack and security controls to a cloud environment, data is exposed to a variety of threats.
 - Another contributing reason is a lack of knowledge of the shared responsibility security Model.
 4. **Insufficient Identity, Credential, Access and Key Management:**
 - Challenges concern with Identity and Access Management (IAM) and particularly to Privileged Access Management (PAM).
 - In cloud contexts, these credentials associated with human users, applications, and machine identities are extremely strong and highly vulnerable to compromise.

- An attacker who obtains or gains access to privileged credentials can acquire complete access to sensitive databases or even the whole cloud environment of an enterprise.
- Many recent IaaS and PaaS attacks have taken advantage of insecure credentials, resulting in data breaches and the loss of intellectual property and other sensitive data.

5. Account Hijacking:

- Malicious attackers use phishing-like methods, vulnerability exploitation, or stolen credentials to gain access to highly privileged accounts in the cloud, such as cloud service accounts or subscriptions.
- Account hijacking means total control of the account, services, and data associated with it.
- The consequences of such a problem might range from major operational and business disruptions to the entire loss of an organization's assets, data, and capabilities.
- To avoid hijacking Defense-in-depth and strong IAM and PAM controls, such as credential lifecycle and provisioning management, as well as segregation of roles, are recommended by the CSA.

6. Insider threat:

- Malicious insiders are the current or former employees, contractors or other trusted third parties who use their access to do such illegal activity.
- Since all such insiders have authentic access, handling such issue is really very difficult and costly.

7. Insecure interfaces and APIs:

- Customers can control and interact with cloud services via a set of software User Interfaces (UIs) and APIs provided by Cloud Computing Providers (CSPs).
- The security and availability of general cloud services are reliant on the APIs' security.
- If such APIs are designed poorly it could lead to misuse or data breach.
- Several major data breaches are caused by broken, exposed, or hacked APIs.

8. Weak Control Plane:

- When a cloud service does not provide enough or sufficient security controls to meet the customer's security requirements, it is referred to as a weak cloud control plane.
- The lack of two-factor authentication and the capacity to enforce its use is an example of a weak control plane.

- A weak control plane means that the person in charge, whether a system architect or a DevOps engineer, does not have complete control over the logic, security, and verification of the data infrastructure.

9. Metastructure and Appliance Failures:

- The CSP/customer line of demarcation, often known as the waterline, is considered the metastructure.
- In this approach, failure is possible at numerous levels.
- For example, a CSP's inadequate API implementation allows attackers to disturb cloud customers by interfering with the service's confidentiality, integrity, and availability.

10. Limited Cloud Usage Visibility:

- It occurs when an organization lacks the ability to visualize and analyze whether cloud service utilization is safe or malicious within the enterprise.
- This concept is broken down into two key challenges.
- **Un-sanctioned app use:** This occurs when employees are using cloud applications and resources without the specific permission and support of corporate IT and security.
- **Sanctioned app misuse:** Organizations are often unable to analyze how their approved applications are being leveraged by insiders who use a sanctioned app.

11. Abuse and Nefarious Use of Cloud Services:

- It refers to attackers who employ cloud computing resources to target users, businesses, and other cloud providers.
- DDoS attacks, phishing, email spam, and gaining access to credential databases are just a few examples.

6.4 SOFTWARE-AS-A-SERVICE SECURITY

- SaaS requires highest level of integrated security. SaaS Security refers to protecting user's privacy and corporate data in subscription based cloud applications.
- The service provider is responsible for securing the platform, network, applications, operating system, and physical infrastructure required for software.
- User's role is also very important while using SaaS.
- SaaS applications carry an enormous amount of sensitive data which can be accessed by any device by anyone, thus posing a risk to privacy and sensitive information.
- Role based access management can ensure that end users do not gain the access to more resources than their requirement.
- Following are the important points regarding the SaaS specific security.

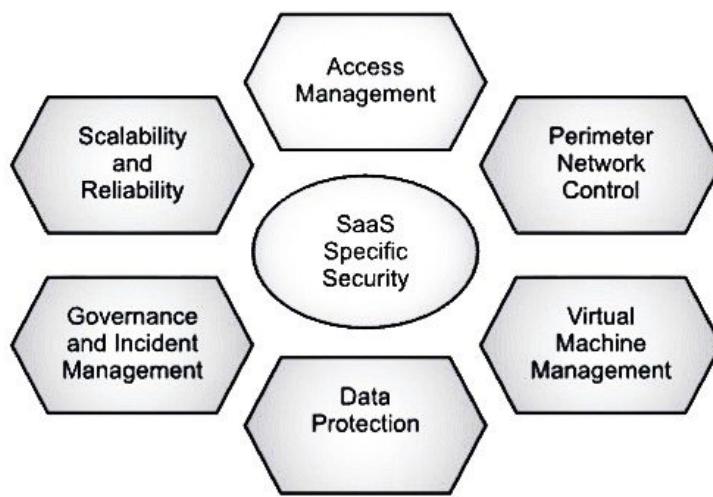


Fig. 6.3: SaaS Specific Securities

1. Access Management:

- Who has the access to the system? (Authentication)
- What kind of access they have? (Authorization)
- The service provider must take care about user access management as per the role and responsibility of user in the organization, independent of devices used to access the software.

2. Perimeter Network Control:

- Security groups can access specific instances across the network.
- Using firewall we can restrict the unusual traffic in the data center.
- It filters out potentially dangerous or unknown traffic that might constitute a threat. Using this, only permitted source and destination addresses are allowed in the network.
- Several organizations also deploy further levels of network protection like intrusion detection and prevention systems to protect the application.

3. Virtual Machine Management:

- To secure your application frequent updates regarding security threats are required and it should be updated time to time.
- SaaS Provider does this task by implementing standardized procedures and taking security measures.

4. Data Protection:

- Many service providers use Data encryption methods to prevent the data breach.
- In many cases customers has the option to control their encryption keys so that cloud operations staff cannot decrypt or access the customer's data.

5. Governance and Incident Management:

- There must be mechanism to trace or capture such incidents regarding the potential security threats.
- Service providers must provide the mechanism to manage such incidents.

6. Scalability & Reliability:

- One of the important advantage of cloud is on demand scalability.
- Horizontal scaling refers to its ability to connect multiple hardware or software entities, such as servers, so that they work as a single logical unit.
- Cloud computing service providers must build a considerable amount of horizontal redundancy into the infrastructure to ensure service availability.

6.5 SECURITY GOVERNANCE

- Cloud security governance means management model that facilitates effective and efficient security management and operations in the cloud environment so that business goals are achieved.
- This model incorporates a hierarchy of executive mandates, performance objectives, operational practices, structures, and metrics that, when applied, optimize an enterprise's business value.
- Strategic alignment, value delivery, risk mitigation, effective use of resources, and performance measurement and security are the key objectives of any IT-related governance model.
- To successfully pursue and achieve these goals, it is necessary to understand an organization's operational culture, as well as its business and customer profiles, in order to create an efficient security governance model for the organization.
- Cloud security governance can help us to answer questions like:
 - Are we getting the desired returns on our security investments?
 - Do we understand our security threats and how they affect our business?
 - Is it true that we're gradually lowering security risks to tolerable levels?
 - Have we created a security-conscious culture in the organisation?
- The following are the key objectives to pursue in establishing a governance model for security in the cloud.
 - **Strategic Alignment:** Cloud security expenditures, services, and efforts should be required by organisations in order to accomplish pre-determined business objectives.
 - **Value Delivery:** Organizations that are implementing cloud services should identify a security function or organization with adequate strategic and tactical

representation, and charge them with maximizing the business value from cloud security activities.

- **Risk Mitigation:** Cloud security initiatives should be evaluated to see how effective they are at reducing risk to the business (Key Risk Indicators). These initiatives should also produce results that show a gradual decrease in these risks over time.
- **Effective Use of Resources:** For overall efficiency and effectiveness, enterprises must establish a practical operating model for managing and performing security operations in the cloud, which includes the proper definition and operationalization of due processes, the establishment of appropriate roles and responsibilities, and the use of relevant tools.
- **Sustained Performance:** Cloud security initiatives should be measurable in terms of performance, value, and risk to the enterprise (Key Performance Indicators, Key Risk Indicators) and produce results that show achievement of intended targets (Key Goal Indicators) over time.

6.6 RISK MANAGEMENT – SECURITY MONITORING

- The assurance that the risk posed by using cloud services is at an acceptable level is based on the organization's trust in the external cloud service provider or broker.
- This Risk Management process ensures that issues are identified and mitigated early in the investment cycle through routine and periodic reviews.
- According to the documentation of National Institute of Standards and Technology (NIST), Risk Management Framework (RMF) provides structured process that integrates information security and risk management activities into the system development life cycle.
- For each identified Step, there is at least one standard that provides guidance.
- The RMF is also consistent with the National Strategy for Trusted Identities in Cyberspace (NSTIC) Identity Ecosystem as it develops.
- This Identity Ecosystem aims to provide a user-centric online environment by combining a set of technologies, regulations, and agreed-upon standards for cloud-based transactions, ranging from anonymous to fully authenticated and authorized.
- The NSTIC Programme is actively working with industry, academia, and government to improve the level of trust associated with online transaction identities.
- Solutions developed through the NSTIC effort may also strengthen a Cloud Ecosystem by addressing certain authentication, authorization, and privacy issues in the Cloud.
- The "Cloud-adapted RMF" highlights the following six steps:

Step 1: Categorize

- Categorization of the information system or service migrated to the cloud, and the information processed, stored, and transmitted by that system based on an impact analysis.

Step 2: Identify

- Identification of security requirements for the information system or service migrated to the cloud.
- Perform a risk assessment, including analysis of Confidentiality, Integrity, and Availability to identify what are the appropriate Security Components for the system.

Step 3: Select

- Selection of the cloud ecosystem architecture that best fits the analysis performed in Step 2 for the information system or service migrated to the cloud.

Step 4: Assess

- Assessment of Service Provider(s) based on their authorization to operate. Identify the security controls needed for the cloud-based information system or service already implemented by the cloud provider, and negotiate the implementation of the additional security components and controls identified as necessary for this system or service.
- When applicable, identify the security controls that remain within the cloud consumer's responsibility, and implement them.

Step 5: Authorize

- Authorize the use of the selected cloud provider for hosting the cloud-based information system or service.
- Negotiate a Service Agreement (SA) and Service Level Agreement (SLA) that reflects the negotiation performed in Step 4.

Step 6: Monitor

- Monitoring the cloud provider to ensure that all SA and SLA terms are met and that the cloud-based information system maintains the necessary security posture.
- Directly monitor the security components and associated controls under the cloud consumer's direct responsibility.

6.7 SECURITY ARCHITECTURE DESIGN

- The cloud security architecture varies based on the type of cloud service model software-as-a-service (SaaS), infrastructure-as-a-service (IaaS), or platform-as-a-service model (PaaS).

- As discussed in previous chapters IaaS is the base of all cloud services next to that PaaS building upon the IaaS. SaaS is on top of PaaS and IaaS.
- Depending on the service type, the shared responsibility model for cloud security splits security duties between the client and the vendor in different ways.
- Single sign-on software, virtual firewalls, and data loss prevention solutions are all useful security tools.

Cloud Computing Security Architectures:**1. IaaS Cloud Computing Security Architecture:**

- This infrastructure provides the storage and networking components to cloud networking.
- IaaS cloud computing service models require these additional security features:
 - Audit and monitor resources for misconfiguration if any.
 - Automate policy correction.
 - Virtual web application firewalls placed in front of a website to protect against malware.
 - Virtual network-based firewalls located at the cloud network's edge that guards the perimeter.
 - Virtual routers.
 - Intrusion Detection Systems (IDS) and Intrusion Prevention Systems (IPS).
 - Network segmentation.

2. SaaS Cloud Computing Security Architecture:

- SaaS means software and data that are accessible via a browser.
- The enterprise normally negotiates with the CSP the terms of security ownership in a legal contract.
- Cloud Access Security Brokers (CASB) play a central role in discovering security issues within a SaaS cloud service model as it logs, audits, provides access control, and oftentimes includes encryption capabilities.
- Enforce Data Loss Prevention (DLP) to prevent unauthorized sharing of sensitive data to wrong people.
- Other security features for the SaaS cloud environment include:
 - Logging
 - IP restrictions
 - API gateways

3. PaaS Cloud Computing Security Architecture:

- The CSP secures a majority of a PaaS cloud service model.
- Security of applications rests with the enterprise.

- The essential components for the PaaS cloud include:
 - Logging
 - IP restrictions
 - API gateways
 - Cloud Access Security Brokers (CASB)

6.7.1 Cloud Security Framework

- Following international frameworks gives important guidelines to the world's IT professionals for implementation of better cloud security:
1. **International Organization for Standardization (ISO):**
 - International standards that offer extensive specifications to consider when establishing a new system.
 - ISOs 27017 and 27018 specifically deal with cloud security.
 2. **National Institute of Standards and Technology (NIST):**
 - It is United States based international organization.
 - Provides both framework checklists for establishing a new system as well as numerous articles on specific problems.
 3. **Cloud Security Alliance (CSA):**
 - CSA is also an International organization which also provides an operational set of standards.
 - It offers very detailed surveys and self-assessment forms for security audits by third parties.

Summary

- As we know cloud computing is based on network so there are more chances of security threats.
- While choosing the cloud service provider it is necessary to check what level of security it offers and what kind of security mechanism implemented.
- Security consists of different policies, controls, actions (procedures) and technologies which work together to keep secure cloud-based systems, data as well as infrastructure.
- Cloud Security Alliance (CSA) stack model defines the boundaries between each service model and shows how different functional units relate to each other.
- One of the biggest challenges during cloud migration is the implementation of appropriate security architecture to survive from cyber-attacks.
- SaaS Security refers to protecting user's privacy and corporate data in subscription based cloud applications or software.

- Cloud security governance means management model that facilitates effective and efficient security management and operations in the cloud environment so that business goals are achieved.
- Risk Management process ensures that issues are identified and mitigated early in the investment cycle with routine and periodic reviews.
- The cloud security architecture varies based on the type of cloud service model software-as-a-service (SaaS), infrastructure-as-a-service (IaaS), or platform-as-a-service model (PaaS).

Check Your Understanding

1. ___ stack model defines the boundaries between each service model and shows how different functional units relate to each other.
 - (a) Cloud Security Alliance (CSA)
 - (b) Infrastructure-as-a-service (IaaS)
 - (c) Platform-as-a-service model (PaaS)
 - (d) Cloud Access Security Brokers (CASB)
2. ___ plays a central role in discovering security issues within a SaaS cloud service model.
 - (a) Cloud Security Alliance (CSA)
 - (b) Cloud Access Security Brokers (CASB)
 - (c) Data Loss Prevention (DLP)
 - (d) Platform-as-a-service model (PaaS)
3. ___ has highest level of integrated security.

(a) SaaS	(b) PaaS
(c) IaaS	(d) CSP
4. A ___ is a security incident in which information is accessed without authorization.

(a) Insider Threat	(b) Weak Control Plane
(c) Account Hijacking	(d) data breach
5. Cloud security is a shared responsibility between the ___ and ___.
 - (a) Cloud service provider; customer
 - (b) Network administrator; User
 - (c) Database administrator; customer
 - (d) Cloud service provider; Internet service provider
6. ___ access management can ensure that end users do not gain the access to more resources than their requirement.

(a) Capability based	(b) Role based
(c) Strength based	(d) On Demand

7. SLA stands for ____.

(a) Service Level Agreement	(b) Security Level Agreement
(c) System Level Agreement	(d) Software Level Agreement
8. IDS stands for ____.

(a) Intrusion Diagnose Systems	(b) Instance Detection Systems
(c) Intrusion Detection Systems	(d) Intrusion Defence Systems
9. NSTIC stands for ____.

(a) National Security for Trusted Identities in Cyberspace	(b) National Strategy for Trusted Identities in Cyberspace
(c) National Strategy for Trusted Instances in Cyberspace	(d) National Society for Trusted Identities in Cyberspace
10. _____ means a management model that facilitates effective and efficient security management and operations in the cloud environment so that business goals are achieved.

(a) Cloud security governance	(b) Cloud security
(c) Cloud Management	(d) Cloud Risk

Answers

1. (a)	2. (b)	3. (a)	4. (d)	5. (a)	6. (b)	7. (a)	8. (c)	9. (b)	10. (a)
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Practice Questions

Q.I Answer the following questions in short.

1. Describes the steps involve in Cloud Risk Management Framework.
2. Describe the Cloud Security Architecture.
3. What are the challenges in Cloud Security?
4. What is the importance of SaaS security?
5. Describe the Concept of Cloud security Governance.

Q.II Answer the following questions.

1. Explain Cloud Security.
2. Write a note on PaaS Cloud Computing Security Architecture, Account Hijacking.
3. What are the insider threats?
4. Write a note on the Limited Cloud Usage Visibility challenge in Cloud Security.
5. Explain cloud security challenges and risks.
6. Explain risk management.

Q.III Define the terms.

1. Cloud Security
2. SaaS Security
3. Security Governance



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