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MIT WORLD PEACE UNIVERSITY | PUNE
TECHNOLOGY, RESEARCH, SOCIAL INNOVATION & PARTNERSHIPS

# CET4034B: Cloud Infrastructure and Security

## SCHOOL OF COMPUTER ENGINEERING AND TECHNOLOGY

### T. Y. B. TECH. CSE(CYBERSECURITY AND FORENSICS)

# CET4034B: Cloud Infrastructure and Security

**Teaching Scheme**
**Theory:** 2 Hrs. / Week

**Credits: 02 + 01 = 03**
**Practical:** 2 Hrs./Week

## Course Objectives

### 1) Knowledge

i. To study basic cloud computing concepts and its operational environment.

### 2) Skills

i. To acquire skills of using various Virtualization Techniques and Platforms
ii. To understand challenges in cloud computing

### 3) Attitude

i. To select and use cloud computing platform

## Course Outcomes

After completion of this course students will be able to

i. Setup a cloud environment
ii. Deploy web services efficiently on a cloud platform
iii. Manage cloud services efficiently and effectively
iv. Design, deploy and address the cloud security aspects

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# Module 3

## Amazon Web Service

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b. The slides should be used only for preparing notes, academic purposes (e.g. in teaching a class), and should not be used for commercial purposes.

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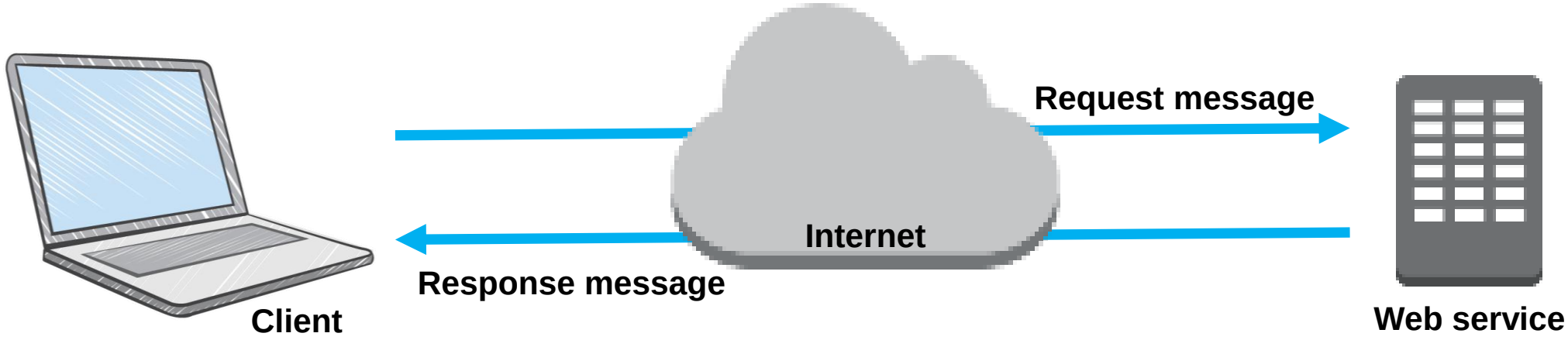
# Points to be covered

- Introduction to AWS
- Services offered by Amazon
- Hands-on Amazon EC2 - Configuring a server
- Virtual Amazon Cloud
- AWS Storage and Content Delivery
- Identify key AWS storage options
- Describe Amazon EBS
- Creating an Elastic Block Store Volume.
- Create an Amazon S3 bucket and manage associated objects.
- AWS Load Balancing Service
- Introduction Elastic Load Balancer
- Creating and Verifying Elastic Load Balancer

# What is Amazon Web Services (AWS)?

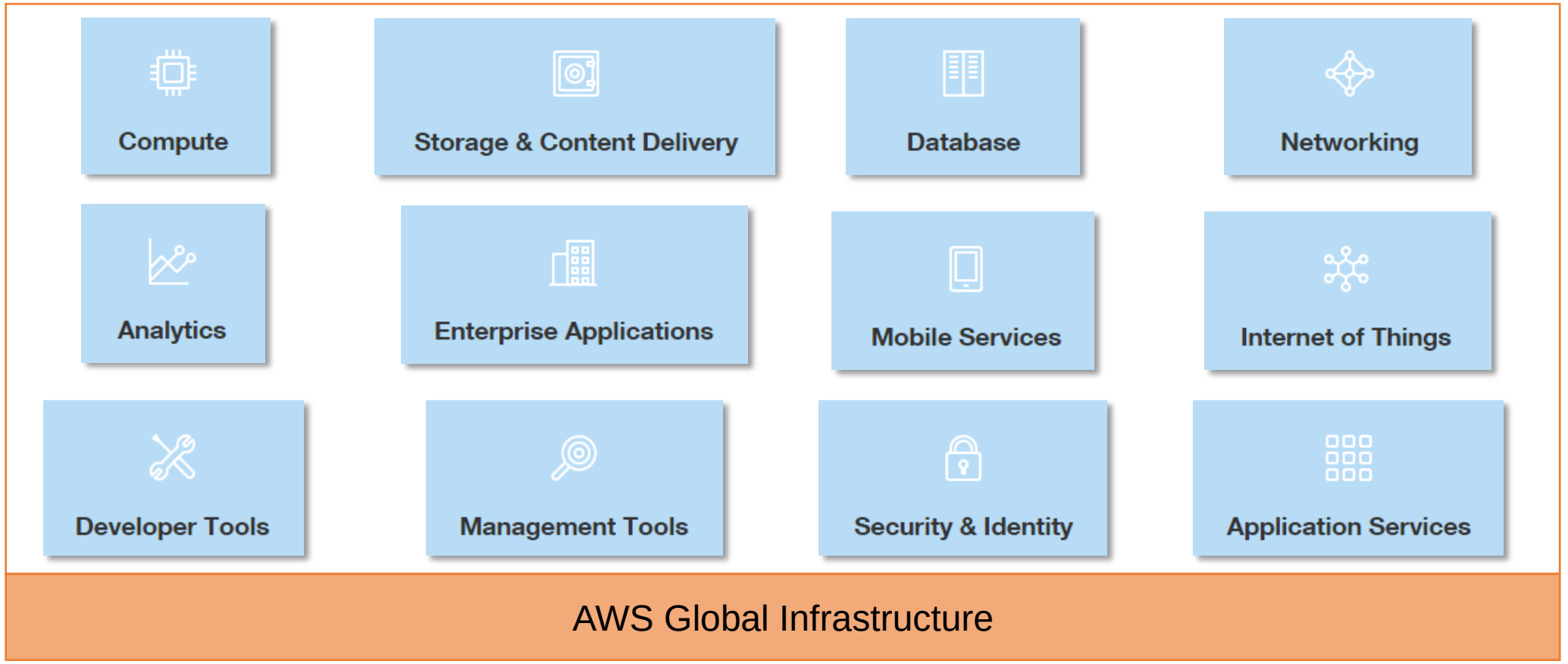
# What are Web Services?

A **web service** is any piece of software that makes itself available over the internet and uses a **standardized format** (XML or JSON) for the request and the response of an **API interaction**.



# What is AWS?

AWS is a secure cloud platform with more than 165 different services that include solutions for:



# AWS by Category: Core Services

## Compute


Amazon EC2


AWS Lambda


Auto Scaling


AWS Elastic Beanstalk


Amazon Elastic Container Registry


Amazon Elastic Container Service


Amazon Lightsail


AWS Batch

## Networking


Amazon VPC


Amazon Route 53


AWS Direct Connect


Elastic Load Balancing

## Storage


Amazon S3


Amazon EBS


Amazon CloudFront


Amazon Glacier


Amazon Elastic File System


AWS Snowball


Storage Gateway


AWS Snowmobile

## Database


Amazon RDS


Amazon DynamoDB


Amazon Redshift


AWS Database Migration Service


Amazon ElastiCache

# AWS by Category: Foundational Services

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## Analytics


Amazon EMR


AWS Data Pipeline


Amazon Elasticsearch


Amazon Kinesis


Amazon Machine Learning


Amazon QuickSight


Amazon Redshift


Amazon Athena

## Enterprise Apps


Amazon WorkSpaces


Amazon WorkMail


Amazon WorkDocs

## Mobile Services


AWS Mobile Hub


Amazon SNS


Amazon Cognito


AWS Device Farm


Amazon Mobile Analytics


AWS Mobile SDKs


Amazon Pinpoint

## Internet of Things


AWS IoT


AWS Greengrass

# AWS by Category: Developer and Operations Services

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## Developer Tools


AWS CodeCommit


AWS CodeDeploy


AWS CodePipeline


AWS CodeBuild


AWS X-Ray

## Management Tools


Amazon CloudWatch


AWS CloudFormation


AWS CloudTrail


AWS Config


AWS OpsWorks


AWS Service Catalog


AWS Trusted Advisor


AWS Organizations

## Security & Identity


AWS Identity and Access Management


AWS Directory Service


Amazon Inspector


AWS CloudHSM


AWS Key Management Service


AWS WAF


AWS Certificate Manager


AWS Shield

## App Services


Amazon API Gateway


Amazon AppStream


Amazon CloudSearch


Amazon Elastic Transcoder


Amazon SES


Amazon SNS


Amazon SQS


Amazon SWF

# Core Services: The Basics

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## Compute


Amazon EC2


AWS Lambda


Auto Scaling


AWS Elastic Beanstalk


Amazon Elastic Container Registry


Amazon Elastic Container Service


Amazon Lightsail


AWS Batch

## Networking


Amazon VPC


Amazon Route 53


AWS Direct Connect


Elastic Load Balancing

## Storage


Amazon S3


Amazon Glacier


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Amazon EBS


Amazon Elastic File System


AWS Snowball


Storage Gateway


AWS Snowmobile

## Database


Amazon RDS


Amazon DynamoDB


Amazon Redshift


AWS Database Migration Service


Amazon ElastiCache

# Core Services: The Basics

## Management Tools


Amazon CloudWatch


AWS CloudFormation


AWS CloudTrail


AWS Config


AWS OpsWorks


AWS Service Catalog


AWS Trusted Advisor

## Security & Identity


AWS Identity and Access Management


AWS Directory Service


Amazon Inspector


AWS CloudHSM


AWS Key Management Service


AWS WAF


AWS Organizations


AWS Certificate Manager


AWS Shield

# Access to AWS Services

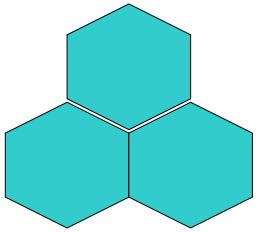
- AWS Management Console
  - Access on the go with AWS Console Mobile App
- AWS Command Line Interface (AWS CLI)
- Software Development Kits (SDK)

# The AWS Cloud Adoption Framework

# AWS Cloud Adoption Framework (CAF)

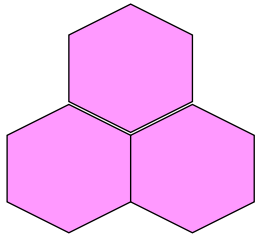

- Perspectives in planning, creating, managing, and supporting a modern IT service
- Guidelines for establishing, developing, and running AWS environments
- Structure for business and IT teams to work together

# Six Core Perspectives



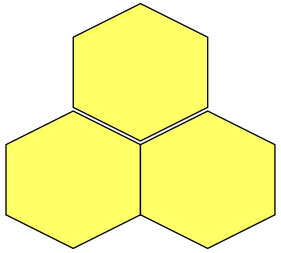
## Business Perspective

How will your architectural approaches **align technical delivery to business imperatives**?



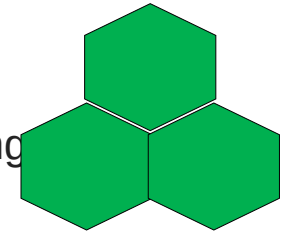
## Platform Perspective

What patterns, guidance, and tools are necessary to optimize your use of **technology services** on AWS?



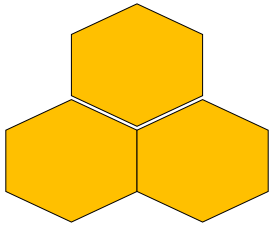
## People Perspective

What **skills** are needed in order to adopt the AWS cloud platform? Examples include guiding processes of role descriptions, training, certification, and mentoring.



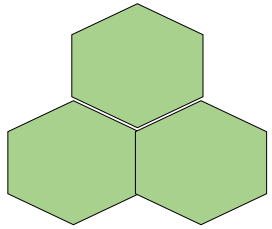
## Security Perspective

How will you define and implement the required levels of security, governance, and risk management to **achieve compliance**?



## Governance Perspective

How to update the staff skills and **organizational processes** necessary to ensure business governance in the cloud, and manage and measure cloud investments to evaluate business outcomes?



## Operations Perspective

How will you provide process, guidance, and tools for optimum **operational service management** of the AWS environment?

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# Introduction to AWS

- Amazon Web Services (AWS) is a leading top platform in providing the web services of various domains.
- It is an expanded cloud computing platform provided by Amazon Company.
- AWS provides a wide range of services with a pay-as-per-use pricing model over the Internet such as Storage, Computing power, Databases, Machine Learning services, and much more.
- AWS facilitates for both businesses and individual users with effectively hosting the applications, storing the data securely, and making use of a wide variety of tools and services improving management flexibility for IT resources.
- It covers a wider range of customers of different domains to expand their business operations.
- Amazon Web Services offers a broad set of global cloud-based products including compute, storage, databases, analytics, networking, mobile, developer tools, management tools, IoT, security, and enterprise applications: on-demand, available in seconds, with pay-as-you-go pricing.

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# Introduction to AWS

- Amazon Web Services(AWS) is a cloud service from Amazon, which provides services in the form of building blocks, these building blocks can be used to create and deploy any type of application in the cloud.
- These services or building blocks are designed to work with each other, and result in applications that are sophisticated and highly scalable.

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# Introduction to AWS

- From data warehousing to deployment tools, directories to content delivery, over 200 AWS services are available.
- New services can be provisioned quickly, without the upfront fixed expense.
- This allows enterprises, start-ups, small and medium-sized businesses, and customers in the public sector to access the building blocks they need to respond quickly to changing business requirements.
- AWS always came with diverse array of services offering with technical innovations, updated services with current trends. AWS has emerged as a powerhouse in the world of Cloud Computing.
- AWS (Amazon Web Services) is the largest cloud computing platform with over 200+ featured resources.
- It is a platform that provides a pay-as-you-go service. Gone are the days when you need to install servers and look after maintenance and cost of them.
- AWS offers a “pay-as-you-go” feature where you just have to pay for the services you use and also the time period you use.

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# How AWS Works?

- AWS comes up with its own network infrastructure on establishing the datacenters in different regions mostly all over the world.
- Its global Infrastructure acts as a backbone for operations and services provided by AWS.
- It facilitates the users on creating secure environments using Amazon VPCs ( Virtual Private Clouds ).
- Essential services like Amazon EC2 and Amazon S3 for utilizing the compute and storage service with elastic scaling.
- It supports the dynamic scaling of the applications with the services such as Auto Scaling and Elastic Load Balancing ( AWS ELB ).
- It provides a good user-friendly AWS Management Console facilitating seamless configuration and management of AWS services to the Users.
- Its Architecture ensures high availability , fault tolerance making AWS as a versatile powerful Cloud Computing Platform.

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# AWS Fundamentals

- In the Journey of AWS, understanding the key concepts such as Regions, Availability Zones, Global Network Infrastructure, etc is crucial. The fundamentals of AWS keep on maintaining the applications reliable and scalable with services globally with coming to a strategic deployment of resources for optimal performance and resilience. The following are the some of the main fundamentals of AWS:
- **Regions:** AWS provide the services with respective division of regions. The regions are divided based on geographical areas/locations and will establish data centers. Based on need and traffic of users, the scale of data centers is depended to facilitate users with low-latencies of servcies.
- **Availability Zones (AZ):** To prevent the Data centers for the Natural Calamities or any other disasters. The Datacenters are established as sub sections with isolated locations to enhance fault tolerance and disaster recovery management.
- **Global Network Infrastructure:** AWS ensures the reliability and scalability of services through setting up its own AWS Network Infrastructure globally. It helps in better management of data transmissions for optimized performance and security reliance.

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# Top AWS Services

- In the rapid revolution of Cloud Computing, AWS facilitates with wide variety of services respect to the fields and needs. The following are the top AWS services that are in wide usage:
- **Amazon EC2(Elastic Compute Cloud) :** It provides the Scalable computing power via cloud allowing the users to run applications and manage the workloads over their remotely.
- **Amazon S3 (Simple Storage Service ):** It offers scalable object Storage as a Service with high durability for storing and retrieving any amount of data.
- **AWS Lambda:** It is a service in Serverless Architecture with Function as a Service facilitating serverless computing i.e., running the code on response to the events, the background environment management of servers is handled by aws automatically. It helps the developers to completely focus on the logic of code build.
- **Amazon RDS (Relational Database Service):** This is an aws service that simplifies the management of database providing high available relational databases in the cloud.
- **Amazon VPC (Virtual Private Cloud):** It enables the users to create isolated networks with option of public and private expose within the AWS cloud, providing safe and adaptable configurations of their resources.
- https://www.geeksforgeeks.org/top-aws-services/

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# Services provided by AWS

Each type of service is categorized under a domain, the few domains which are widely used are:

- Compute
- Storage
- Database
- Migration
- Network and Content Delivery
- Management Tools
- Security & Identity Compliance
- Messaging

## Compute Services

The Compute domain includes services related to compute workloads, it includes the following services:

- EC2 (Elastic Compute Cloud)
- Lambda
- Elastic Beanstalk
- Amazon LightSail

## Storage Services

The Storage domain includes services related data storage, it includes the following services:

- S3 (Simple Storage Service)
- Elastic Block Store
- Amazon Glacier
- AWS Snowball

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# Database Services

The Database domain is used for database related workloads, it includes the following services:

- Amazon Aurora
- Amazon RDS
- Amazon DynamoDB
- Amazon RedShift

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## Advantages Of Amazon Web Services

- AWS allows you to easily scale your resources up or down as your needs change, helping you to save money and ensure that your application always has the resources it needs.
- AWS provides a highly reliable and secure infrastructure, with multiple data centers and a commitment to 99.99% availability for many of its services.
- AWS offers a wide range of services and tools that can be easily combined to build and deploy a variety of applications, making it highly flexible.
- AWS offers a pay-as-you-go pricing model, allowing you to only pay for the resources you actually use and avoid upfront costs and long-term commitments.

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## Disadvantages Of Amazon Web Services

- AWS can be complex, with a wide range of services and features that may be difficult to understand and use, especially for new users.
- AWS can be expensive, especially if you have a high-traffic application or need to run multiple services. Additionally, the cost of services can increase over time, so you need to regularly monitor your spending.
- While AWS provides many security features and tools, securing your resources on AWS can still be challenging, and you may need to implement additional security measures to meet your specific requirements.
- AWS manages many aspects of the infrastructure, which can limit your control over certain parts of your application and environment.

# Applications Of AWS

- The AWS services are using by both startup and MNC companies as per their usecase. The startup companies are using overcome hardware infrasture cost and applications deployments effectively with cost and performance. Whereas large scale companies are using AWS cloud services for the management of their Infrastructure to completely focus on the development of products widely. The following the Real-world industrial use-cases of AWS services:
- **Netflix:** The Large streaming gaint using AWS for the storage and scaing of the applications for ensuring seamless content delivery with low latency without interruptions to millions of users globally.
- **Airbnb:** By utilizing AWS, Airbnb manages the various workloads and provides insurable and expandable infrastructure for its virtual marketplace and lodging offerings.
- **NASA's Jet Propulsion Laboratory:** It takes the help of AWS services to handle and analyze large-scale volumes of data related to vital scientific research missions and space exploration.
- **Capital One:** A financial Company that is utilizing AWS for its security and compliance while delivering innovative banking services to its customers.

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# AWS Cloud Computing Models

There are three cloud computing models available on AWS.

- **Infrastructure as a Service (IaaS):** It is the basic building block of cloud IT. It generally provides access to data storage space, networking features, and computer hardware (virtual or dedicated hardware). It is highly flexible and gives management controls over the IT resources to the developer. For example, VPC, EC2, EBS.

- **Platform as a Service (PaaS):** This is a type of service where AWS manages the underlying infrastructure (usually operating system and hardware). This helps the developer to be more efficient as they do not have to worry about undifferentiated heavy lifting required for running the applications such as capacity planning, software maintenance, resource procurement, patching, etc., and focus more on deployment and management of the applications. For example, RDS, EMR, ElasticSearch.

- **Software as a Service(SaaS):** It is a complete product that usually runs on a browser. It primarily refers to end-user applications. It is run and managed by the service provider. The end-user only has to worry about the application of the software suitable to its needs. For example, Saleforce.com, Web-based email, Office 365 .

# Hands on Amazon EC2- Configuring a Server

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# Amazon EC2- Configuring a Server

https://runcloud.io/blog/aws

# Virtual Amazon Cloud

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# Virtual Amazon Cloud

- Amazon Virtual Private Cloud (Amazon VPC) is a virtual network service provided by Amazon Web Services (AWS) that enables users to launch AWS resources into a virtual network that they have defined.
- This allows users to have complete control over their virtual networking environment, including the ability to create subnets, configure security groups, and assign IP addresses.
- Benefits of using Amazon VPC
  - Ability to extend your own on-premises data centre into the cloud.
  - Allows you to seamlessly connect your existing infrastructure with AWS resources
  - Enabling you to leverage the scalability and flexibility of the cloud while maintaining control over your data and network security.
  - Ability to isolate your resources from other users on the same physical infrastructure.
- Each Amazon VPC is logically isolated from other virtual networks in the AWS Cloud, allowing you to create a virtual network that is completely separate from other networks.
- This can be particularly useful for security and compliance purposes, as it allows you to create a secure and isolated environment for your resources.

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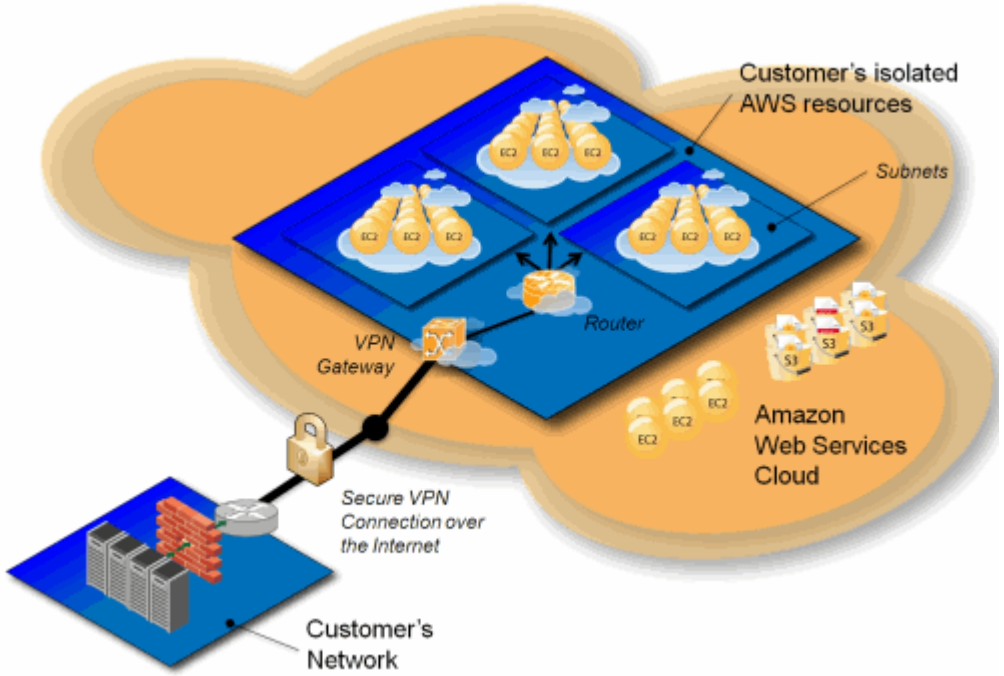
# Introducing Amazon Virtual Private Cloud (VPC)

- Amazon VPC lets you create your own logically isolated set of Amazon EC2 instances and connect it to your existing network using an IPsec VPN connection.
- This new offering lets you take advantage of the low cost and flexibility of AWS while leveraging the investment you have already made in your IT infrastructure.



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# Networking Services offered by VPC

In addition to creating and configuring your own virtual network, Amazon VPC also provides a range of networking services that can be used to connect your resources. These services include :

- **Virtual Private Network (VPN) connections**: Allows you to create a secure, encrypted connection between your on-premises data centre and your Amazon VPC.
- **Direct Connect:** This enables you to establish a dedicated network connection between your on-premises data centre and your Amazon VPC.
- **Elastic IP addresses**: Allows you to allocate a static IP address to your Amazon VPC, which can be used to connect to your resources from the internet.
- **Gateway**: Provides a connection between your Amazon VPC and the internet.
- **Summary:**
  - Overall, Amazon VPC is a powerful and flexible service that provides a range of options for creating and managing your own virtual network in the cloud.
  - Whether you want to extend your on-premises data centre into the cloud, create a secure and isolated environment for your resources, or simply need a way to connect your resources to the internet, Amazon VPC has you covered.

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# Steps for Creating your own VPC

1. Sign in to the AWS Management Console and navigate to the Amazon VPC dashboard.
2. To start the creation process click the "Create VPC" button
3. Enter a name and a CIDR block for your VPC. The CIDR block defines the range of IP addresses that will be available to your VPC.
4. Select whether you want to enable Amazon Elastic Container Service for Kubernetes (EKS) for your VPC. EKS is a service that allows you to run Kubernetes clusters on AWS.
5. Now to create your VPC click the "Create VPC" button.
6. Once your VPC has been created, you can create subnets within it. To do this, click the "Subnets" link in the left-hand menu and then click the "Create Subnet" button.
7. Enter a name and a CIDR (Classless Inter-Domain Routing) block for your subnet, and select the VPC and availability zone in which you want to create it.
8. Click the "Create Subnet" button to create your subnet.
9. Repeat this process to create additional subnets as needed.
10. Once your subnets have been created, you can launch resources such as EC2 instances, RDS databases, and more into your VPC.

**By following these steps, you can create your own VPC and customize it to meet the needs of your application or workload.**

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# Custom VPC

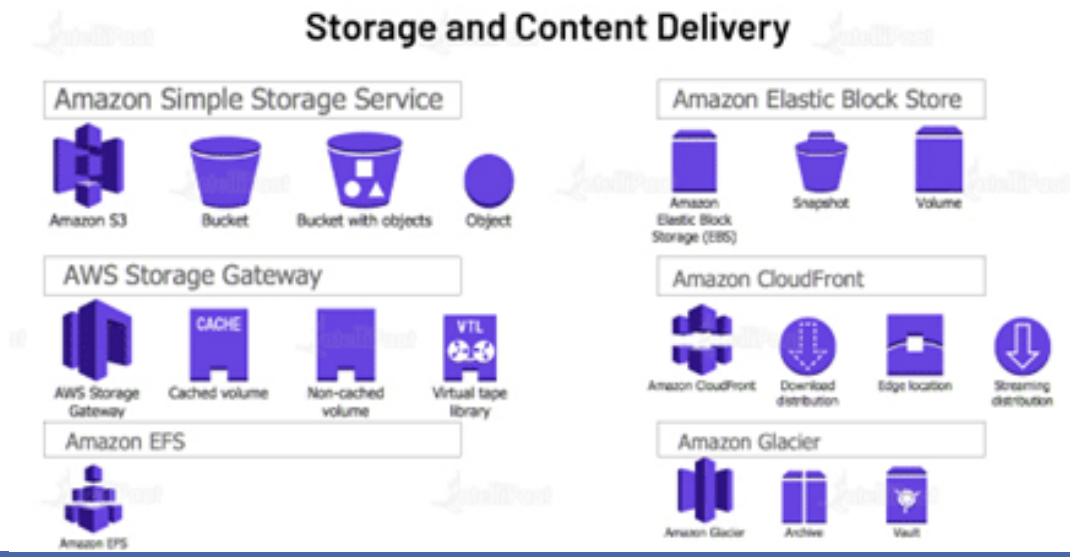
- A custom Virtual Private Cloud (VPC) in Amazon Web Services (AWS) is a virtual network that you create and configure to meet the specific needs of your application or workload.
- With a custom VPC, you have complete control over the IP address range, subnets, and network gateways for your virtual network.
- A custom VPC allows you to create a virtual network that is logically isolated from other virtual networks in the AWS Cloud.
- This can be particularly useful for security and compliance purposes, as it allows you to create a secure and isolated environment for your resources.

For more information visit:

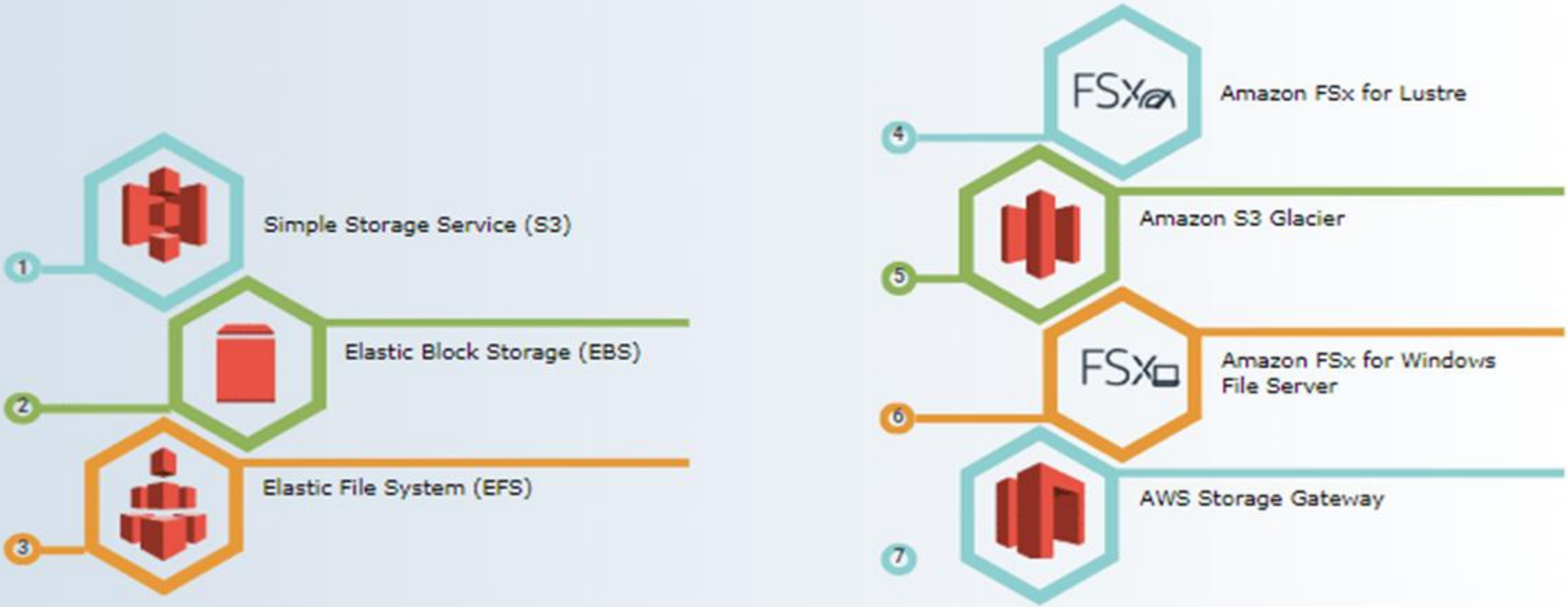
1. https://aws.amazon.com/blogs/aws/introducing-amazon-virtual-private-cloud-vpc/
2. https://www.mygreatlearning.com/aws/tutorials/aws-vpc

# AWS Storage and Content Delivery

- AWS offers several tools and solutions for enterprises and software developers that can be used in data centers.
- It provides servers, storage, networking, remote computing, email, mobile development, and security.
- **Storage and Content Delivery** are a few of the prominent services provided by Amazon.
  - AWS offers a variety of services to meet customers' storage needs, such as
    - Amazon Simple Storage Service,
    - Amazon CloudFront,
    - AWS Storage Gateway,
    - Amazon Glacier, and
    - Amazon Elastic Block Store.



# AWS Storage Services



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# Key Services

- **Amazon Web Services suggests a wide variety of services to fulfill the storage requirements**

| Key Services | Description |
|---|---|
| Amazon S3 | With the help of S3, you can store and analyze data in any form. Data is stored in the form of files which in turn are stored in S3 buckets. |
| CloudFront | It is a web service, with which you can speed up distributing the inert and active web content, e.g., .html, .php files, etc., to clients. |
| Amazon EBS | Amazon Elastic Block Store is known as a block storage system of AWS. It is used to store persistent data. |
| Amazon Glacier | It is designed to store infrequently used data. It is also a low-cost storage service |
| Amazon EFS | Amazon EFS or Elastic File Storage is used to structure the complex file system of your architecture |
| Amazon Storage Gateway | As the name suggests, Storage Gateway acts as a gateway between your on-premises data storage and the cloud |

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# Amazon Simple Storage Service

- Amazon Simple Storage Service is also called **Amazon S3** in short.
- It offers developers and IT teams high durability and scalability object storage that handles unlimited amounts of data virtually and a very high amount of concurrent users.
- It enables organizations to store huge amounts of objects of any type, like source code files, HTML pages, image files, and encrypted data, and access them through HTTP-based protocols.
- Amazon S3 allows cost-effective object storage for a wide variety of use cases, involving backup and recovery, nearline archive, disaster recovery, big data analytics, cloud applications, and content distribution.

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# How Amazon Simple Storage Service works

- In Amazon Simple Storage Service, data is stored as objects.
- Objects are the basic entities of data storage in Amazon S3 buckets and a bucket is a fundamental logical container where data is stored in Amazon S3 storage.
- Objects can be placed on several physical disk drives distributed over the data center.
- It provides redundancy and version control using block storage methods.
- Data is stored automatically in multiple locations, distributed across multiple disks, and in some cases, multiple availability regions or zones.
- The Amazon S3 service verifies the integrity of the data periodically by checking its control hash value.
- If there is data corruption, the object is restored using redundant data.

# How Amazon Simple Storage Service works


## Use cases

Below we describe a few specific use cases of Amazon S3:

1. **To back up and restore data**

Because of Amazon S3, meeting Recovery Time Objectives (RTO), Recovery Point Objectives (RPO), and compliance requirements with S3's robust replication features become very easy.

**2. To run cloud-native applications**

It enables the building of fast, powerful mobile and web-based cloud-native apps that scale automatically in a highly available configuration.

**3. To build a data lake**

It is used to run big data analytics, artificial intelligence (AI), machine learning (ML), and high-performance computing (HPC) applications to unlock data insights.

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## Amazon CloudFront

- It is one of the Content Delivery web services that integrate with other AWS Cloud services to provide businesses and developers an easy way to distribute content to users across the world with high data transfer speeds, low latency, and no minimum usage commitments.
- Amazon CloudFront can also be employed to deliver the entire website, including static, dynamic, interactive content, and streaming, using a global network of edge locations.
- All the requests for content are automatically routed to the nearest edge location, therefore the content is transferred with the best possible performance to the end-users around the globe.

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# AWS Key Storage options

- Identify Describe Amazon EBS

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# Amazon EBS

- Amazon Elastic Block Store (EBS) is a block storage service that provides raw block-level storage for Amazon Elastic Compute Cloud (EC2) instances.
- EBS is designed for use with Amazon EC2 and is intended for use as the primary storage for persistent data.
- EBS provides high-performance storage for applications that require a low-latency connection, such as databases and file systems.
- It also offers the ability to take point-in-time snapshots of your data, which can be used for backup and disaster recovery.

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## Key features of EBS

- **Performance:** EBS offers a range of performance options, including standard, provisioned IOPS (Input/Output Operations Per Second), and, throughput-optimized volumes, to meet the needs of different workloads.
- **Durability:** EBS stores data across multiple devices in a single availability zone, and is designed to sustain the loss of a single device.
- **Security:** EBS supports encryption for data at rest and in transit
- **Integration**: EBS integrates with a wide range of AWS services, making it easy to use as a storage layer for applications and workloads.

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# Creating an Elastic Block Store Volume / Working with EBS

- To get started with EBS, you will need to create an EBS volume and attach it to an EC2 instance. You can create an EBS volume using the AWS Management Console, the AWS CLI, or the EC2 API.
- Here is a tutorial on how to use EBS in AWS:
- **EBS Volume:**

- Open the AWS Management Console and Navigate the EC2 dashboard.
- From the left-hand menu, select "Elastic Block Store" and then choose "Volumes."
- To create a new EBS volume click the "Create Volume" button.
- Select the desired volume type and size, and specify the availability zone in which you want to create the volume.
- Click "Create Volume" to create the volume.
- To attach the volume to an EC2 instance, select the volume and choose "Actions," then select "Attach Volume."
- Select the desired EC2 instance and specify the device name that you want to use to mount the volume.
- Click "Attach" to attach the volume to the EC2 instance.
- SSH into the EC2 instance and use the Linux “fdisk” command to create a new partition on the volume.
- Use the Linux “mkfs” command to create a file system on the volume (e.g. ext4).
- Use the Linux “mount” command to mount the volume to a directory on the EC2 instance.
- You can now use the mounted volume to store data for your applications.

https://www.mygreatlearning.com/aws/tutorials/amazon-elastic-block-store-ebs

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# Amazon S3 bucket

- . An Amazon S3 bucket is a public cloud storage resource available in Amazon Web Services (AWS) Simple Storage Service (S3) platform. It provides object-based storage, where data is stored inside S3 buckets in distinct units called objects instead of files.
- Amazon S3 buckets are similar to file folders and can be used to store, retrieve, back up and access objects. Each object has three main components -- the object's content or data, a unique identifier for the object and the descriptive metadata, including the object's name, URL and size.
- An object must exist within a bucket, as it can't exist alone. Each Amazon account could have hundreds of buckets, each containing numerous objects.

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# What are S3 buckets used for?

- Amazon's Simple Storage Service buckets are mainly used to help individuals and enterprises meet their data storage, backup and delivery needs in the cloud.
- An infinite amount of data can be stored and protected using Amazon S3 buckets for a variety of use cases:
  - Data lakes.
  - Dynamic websites.
  - Mobile applications.
  - Backup and restore operations.
  - Big data analytics.
  - User-generated content.
  - Storage archives.
  - Enterprise applications.
  - IoT devices.

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# How to use an S3 bucket

- An S3 user first creates a bucket in the AWS region of their choice and gives it a globally unique bucket name. It's crucial to know that Amazon S3 buckets are globally unique, which means that the bucket names of any two AWS accounts in the same region can't be the same. AWS recommends that users choose regions geographically close to them to reduce latency and storage costs.
- Once the bucket is created, the user selects a tier for the data. Different S3 tiers have different levels of redundancy, pricing and accessibility. One bucket can store objects from different S3 storage tiers.
- Next the user specifies access privileges for the objects stored in a bucket using the AWS identity and access management service, bucket policies or access control lists (ACLs).
- An AWS user can interact with an Amazon S3 bucket via the AWS Management Console, AWS Command Line Interface or application programming interfaces (APIs). The S3 access points that have the Amazon Resource Names and the bucket hostname can be used to access objects inside a bucket.

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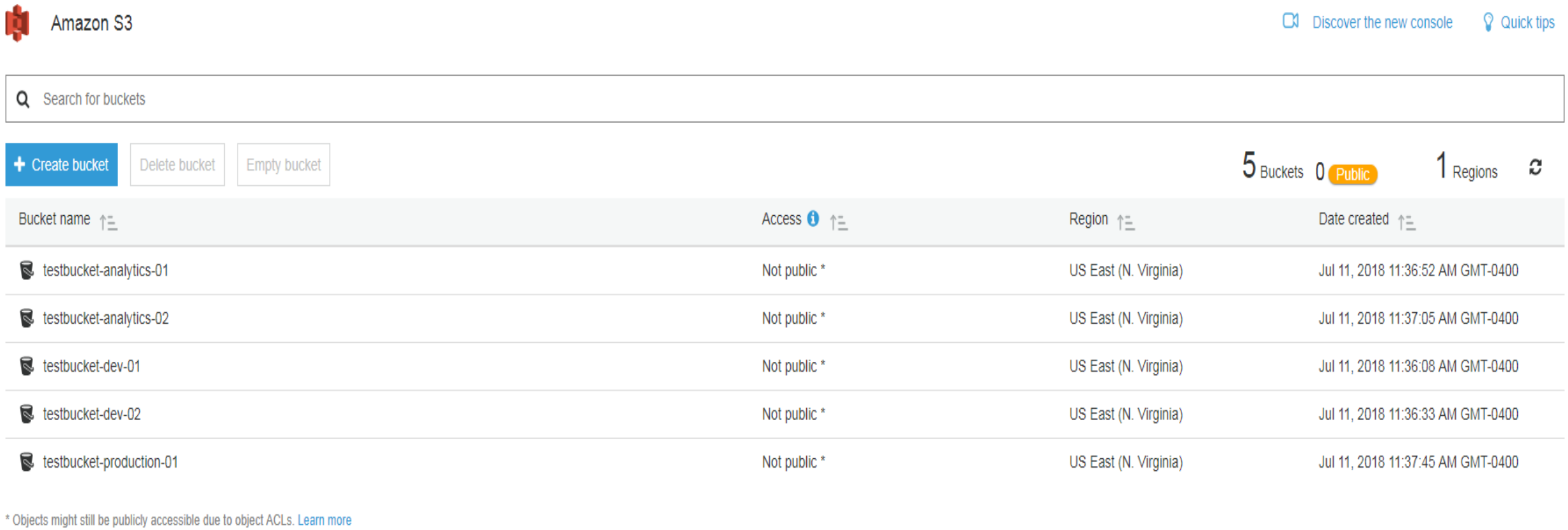
# How to use an S3 bucket



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# S3 bucket features

- Amazon S3 offers numerous features to manage and organize data and support particular use cases.

**Commonly used features that can be enabled for S3 buckets include the following:**

- **Versioning control.** Versioning control can preserve every version of an object when a user performs an operation, such as copy or delete. This helps prevent the object from being accidently deleted. Multi-factor authentication can also be enabled on an S3 bucket to prevent accidental deletions.
- **Object ownership.** This bucket-level setting can be used to disable ACLs and to take ownership of every object inside a bucket, streamlining access management for data stored in Amazon S3. By default, when a user uploads an object to another Amazon account's S3 bucket, that account -- the object writer -- automatically becomes the owner of the object, has access to it and can grant other users access to it through ACLs. However, this default behavior can be modified by the bucket owner by using the Object Ownership feature.
- **Object replication.** The Amazon S3 Replication feature can replicate objects between buckets. Amazon S3 can be configured to automatically replicate S3 bucket objects across different AWS regions using S3 Cross-Region Replication. For buckets that need to be replicated within the same AWS region, Same-Region Replication is used.
- **Transfer Acceleration**. This feature helps execute fast, secure transfers from a client to an S3 bucket via AWS edge locations.
- **Block Public Access.** A set of security controls called S3 Block Public Access ensures that the general public can't access S3 buckets and objects. These settings can be easily applied to all buckets in the AWS account or specific S3 buckets with just a few clicks in the Amazon S3 Management Console.
- **Audit logs.** A user can configure an Amazon S3 bucket to capture all access log entries made to it. These server access logs are great for auditing, as they keep track of every request made against a bucket or the objects it contains.
- **Object tagging.** Users can restrict and manage access to S3 objects using the Amazon S3 Tagging feature. These tags are key-value pairs that can be added to, changed or removed from S3 objects at any point in their lifespan. They enable the creation of identity and access management (IAM) policies, the configuration of S3 lifecycle policies and the customization of storage metrics.

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# Bucket configurations

- Amazon S3 supports a variety of configuration options for buckets. For example, a user can configure their bucket for website hosting, add a configuration to control the object lifecycle in the bucket or configure the bucket to record all accesses to it.
- Amazon S3 supports sub-resources so users can store and manage bucket configuration data. Users can also create and manage these sub-resources using the Amazon S3 API. However, they can also use the AWS console or the Amazon SDKs for this purpose.
- When setting up S3 buckets, the bucket owner can also create object-level configurations. For example, by setting up an ACL that's unique to an object, the owner of the bucket can specify object-level permissions.

# Bucket permission options

By default, only the owner of the bucket can access the buckets and resources inside them. However, a bucket owner can grant cross-account permissions to another AWS account or users in another account to upload objects.

For objects stored inside a bucket, access privileges are typically granted through the following permission options:

- **Bucket policies.** The bucket owner can use a bucket policy to grant permissions to the bucket and any objects inside the bucket that belong to the owner. A bucket policy can be easily created using the AWS Policy Generator.
- **AWS Identity and Access Management service.** The AWS IAM web service lets users securely manage who has access to their Amazon S3 buckets and other AWS resources. Several users can be created under the same Amazon account using AWS IAM and user policies can be linked to these accounts to control S3 object access permissions.
- **ACLs.** In addition to bucket policies and IAM-based user policies, ACLs can be used to limit access to objects in an S3 bucket. Both S3 buckets and objects have ACLs that can be used to grant access to S3 objects.

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# S3 pros

- **High availability.** The availability of a service is determined by how easily and readily it can be used. To guarantee high availability, AWS availability zones or regions are spread across several countries across the globe.
- **Limitless server capacity.** Amazon S3 provides unlimited server capacity, letting users store data without having to worry about hard drive failures or other service interruptions.
- **Ease of use.** Amazon S3 cloud storage is extremely user friendly and comes with an intuitive interface. It's specifically designed for fast, secure access and comes with a wealth of documentation, videos and information to help users get started with the service even if they don't have prior experience using cloud services.
- **Durability.** The probability of data loss is measured by durability. All of Amazon's services, including Amazon S3, are extremely durable. The durability of the S3 Standard Tier is 99.999999999%, which essentially means that if 100 billion objects are stored in S3, at most, only one object would be lost. For example, the data in S3 buckets is preserved even if two data centers fail simultaneously.
- **Security.** S3 provides many security and data protection options. Virtual private cloud endpoints enable users to connect to their S3 resources from their Amazon Virtual Private Cloud (Amazon VPC). Automatic encryption of data is also provided as soon as the data uploading process is finished. Various other security options are also offered, such as IAM, which enables only a certain person to access information. Also, bucket owners can monitor who is accessing their data and obtain information such as the location of access, time and device accessing the platform.
- **Different storage classes.** For diverse demands and requirements, AWS offers S3 Intelligent-Tiering in a variety of S3 storage classes, including Standard for frequent usage, Infrequent Access storage for infrequent use and Glacier, which is Amazon's long-term storage platform.
- **Horizontal scaling.** Amazon S3 scales horizontally, distributing data across multiple servers to handle massive volumes of data and requests. Horizontal scaling enables concurrent connections and auto-partitioning to boost its capacity and performance.

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# S3 cons

- **No directories.** No concept of directories and directory-like structures exist in S3. The "/" character is only a component of the key name or the object name.
- **Data retrieval.** Since an S3 bucket isn't a local disk, data retrieval requires sending queries via the internet or the internal network of AWS. Due to the nature of the internet, this can occasionally result in delays and possible request failures.
- **Object store.** S3 isn't a file system but just an object store. Therefore it can never be treated as a Portable Operating System Interface file system.
- **Latency and availability.** S3 isn't a real-time storage service even though it's designed for high durability and availability. When accessing S3 data, users could encounter some latency and downtime, especially when there's a spike in demand or an infrastructure problem.
- **Limited data management.** S3 lacks built-in data management tools such as version control, backup and recovery, and data compression because it's essentially a data storage service. To meet these objectives, users can create these functionalities themselves or use other AWS services built for these specific uses.
- **Complex billing.** For small business owners who aren't particularly tech-savvy, billing for most Amazon services, including S3, can be complex and difficult to understand. However, most consumers eliminate this problem by working with resellers, who make the billing procedure more intuitive and easier for the end-user to comprehend.

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# Create an Amazon S3 bucket and manage associated objects

https://docs.aws.amazon.com/AmazonS3/latest/userguide/creating-bucket.html

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# AWS Load Balancing Service

- **Load balancing** is the method of distributing network traffic equally across a pool of resources that support an application.
- Modern applications must process millions of users simultaneously and return the correct text, videos, images, and other data to each user in a fast and reliable manner.
- To handle such high volumes of traffic, most applications have many resource servers with duplicate data between them.
- A load balancer is a device that sits between the user and the server group and acts as an invisible facilitator, ensuring that all resource servers are used equally.

https://aws.amazon.com/what-is/load-balancing/

# What are the benefits of load balancing?

- Load balancing directs and controls internet traffic between the application servers and their visitors or clients. As a result, it improves an application's availability, scalability, security, and performance.
- **Application availability**
- Server failure or maintenance can increase application downtime, making your application unavailable to visitors. Load balancers increase the fault tolerance of your systems by automatically detecting server problems and redirecting client traffic to available servers. You can use load balancing to make these tasks easier:
  - Run application server maintenance or upgrades without application downtime
  - Provide automatic disaster recovery to backup sites
  - Perform health checks and prevent issues that can cause downtime

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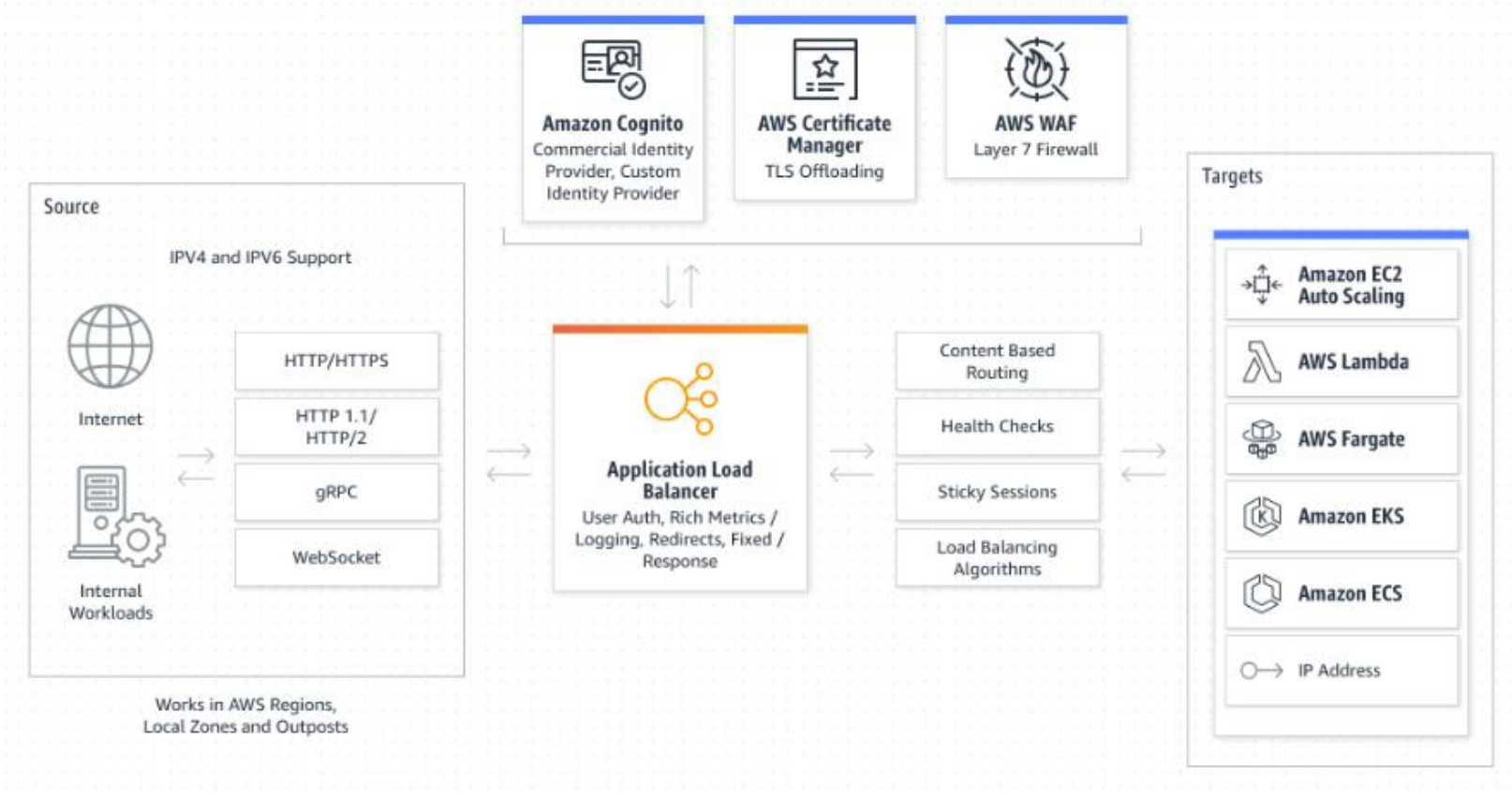
# What are the benefits of load balancing?

- **Application scalability**
- You can use load balancers to direct network traffic intelligently among multiple servers.
- Your applications can handle thousands of client requests because load balancing does the following:
  - Prevents traffic bottlenecks at any one server
  - Predicts application traffic so that you can add or remove different servers, if needed
  - Adds redundancy to your system so that you can scale with confidence
- **Application security**
  - Load balancers come with built-in security features to add another layer of security to your internet applications. They are a useful tool to deal with distributed denial of service attacks, in which attackers flood an application server with millions of concurrent requests that cause server failure.
- **Application performance**
  - Load balancers improve application performance by increasing response time and reducing network latency.

# How does load balancing work?

- Companies usually have their application running on multiple servers.
- Such a server arrangement is called a server farm. User requests to the application first go to the load balancer. The load balancer then routes each request to a single server in the server farm best suited to handle the request.
- Load balancing is like the work done by a manager in a restaurant. Consider a restaurant with five waiters. If customers were allowed to choose their waiters, one or two waiters could be overloaded with work while the others are idle. To avoid this scenario, the restaurant manager assigns customers to the specific waiters who are best suited to serve them.



# What are the types of load balancing?

- We can classify load balancing into three main categories depending on what the load balancer checks in the client request to redirect the traffic.

- **Application load balancing**

  Complex modern applications have several server farms with multiple servers dedicated to a single application function. Application load balancers look at the request content, such as HTTP headers or SSL session IDs, to redirect traffic.

  For example, an ecommerce application has a product directory, shopping cart, and checkout functions. The application load balancer sends requests for browsing products to servers that contain images and videos but do not need to maintain open connections. By comparison, it sends shopping cart requests to servers that can maintain many client connections and save cart data for a long time.

- **Network load balancing**

  Network load balancers examine IP addresses and other network information to redirect traffic optimally. They track the source of the application traffic and can assign a static IP address to several servers. Network load balancers use the static and dynamic load balancing algorithms described earlier to balance server load.

- **Global server load balancing**

  Global server load balancing occurs across several geographically distributed servers. For example, companies can have servers in multiple data centers, in different countries, and in third-party cloud providers around the globe. In this case, local load balancers manage the application load within a region or zone. They attempt to redirect traffic to a server destination that is geographically closer to the client. They might redirect traffic to servers outside the client's geographic zone only in case of server failure.

- **DNS load balancing**

  In DNS load balancing, you configure your domain to route network requests across a pool of resources on your domain. A domain can correspond to a website, a mail system, a print server, or another service that is made accessible through the internet. DNS load balancing is helpful for maintaining application availability and balancing network traffic across a globally distributed pool of resources.

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# Types of load balancing technology

Load balancers are one of two types: hardware load balancer and software load balancer.

- **Hardware load balancers**

  A hardware-based load balancer is a hardware appliance that can securely process and redirect gigabytes of traffic to hundreds of different servers. You can store it in your data centers and use virtualization to create multiple digital or virtual load balancers that you can centrally manage.

- **Software load balancers**

  Software-based load balancers are applications that perform all load balancing functions. You can install them on any server or access them as a fully managed third-party service.

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# Comparison of hardware balancers to software load balancers

- Hardware load balancers require an initial investment, configuration, and ongoing maintenance.
- You might also not use them to full capacity, especially if you purchase one only to handle peak-time traffic spikes.
- If traffic volume increases suddenly beyond its current capacity, this will affect users until you can purchase and set up another load balancer.
- In contrast, software-based load balancers are much more flexible.
- They can scale up or down easily and are more compatible with modern cloud computing environments.
- They also cost less to set up, manage, and use over time.

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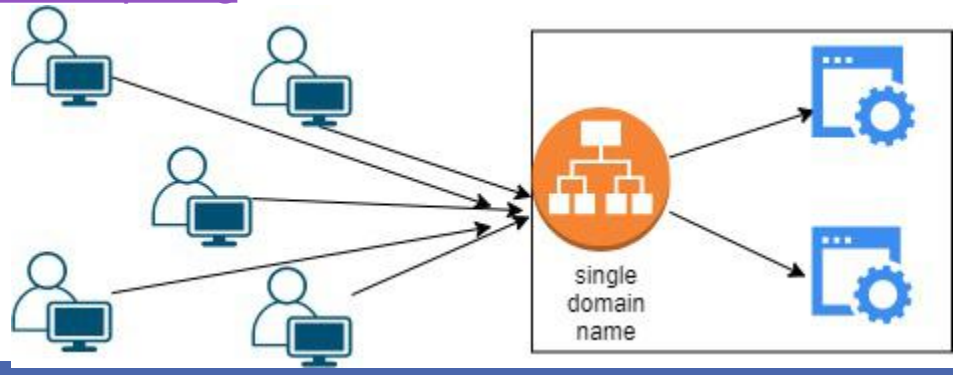
# Elastic Load Balancer

- Elastic Load Balancing (ELB) is a fully managed load balancing service that automatically distributes incoming application traffic to multiple targets and virtual appliances across AWS and on-premises resources. You can use it to scale modern applications without complex configurations or API gateways. You can use ELB to set up four different types of software load balancers.
  - An Application Load Balancer routes traffic for HTTP-based requests.
  - A Network Load Balancer routes traffic based on IP addresses. It is ideal for balancing TCP and User Datagram Protocol (UDP)-based requests.
  - A Gateway Load Balancer routes traffic to third-party virtual appliances. It is ideal for incorporating a third-party appliance, such as a network firewall, into your network traffic in a scalable and easy-to-manage way.
  - A Classic Load Balancer routes traffic to applications in the Amazon EC2-Classic network—a single, flat network that you share with other customers.
- You can select the load balancer based on your requirements. For example, Terminix, a global pest control brand, uses Gateway Load Balancer to handle 300% more throughput. Second Spectrum, a company that provides artificial intelligence-driven tracking technology for sports broadcasts, uses AWS Load Balancer Controller to reduce hosting costs by 90%. Code.org, a nonprofit dedicated to expanding access to computer science in schools, uses Application Load Balancer to handle a 400% spike in traffic efficiently during online coding events.

# Elastic Load Balancing

- The elastic load balancer is a service provided by Amazon in which the incoming traffic is efficiently and automatically distributed across a group of backend servers in a manner that increases speed and performance.
- It helps to improve the scalability of your application and secures your applications.
- Load Balancer allows you to configure health checks for the registered targets.
- In case any of the registered targets (Autoscaling group) fails the health check, the load balancer will not route traffic to that unhealthy target.
- Thereby ensuring your application is highly available and fault tolerant.
- To know more about load balancing refer to Load Balancing in Cloud Computing




https://www.geeksforgeeks.org/elastic-load-balancer-in-aws/

https://www.clickittech.com/aws/aws-load-balancer/

# Creating and Verifying Elastic Load Balancer

- **Create an Elastic Load Balancer (ELB)**
- Elastic Load Balancing automatically distributes and balances the incoming application traffic among all the instances you are running, thus improving the availability and scalability of your application. It seamlessly provides load balancing capacity. You create a load balancer and register instances with it which serves as a single point of contact for clients. The addition and deletion of EC2 instances from the load balancer can be done without disturbing the flow of information.
- If the call completes successfully, a new load balancer is created with a unique Domain Name Service (DNS) name. The load balancer receives incoming traffic and routes it to the registered instances. You can create up to 20 load balancers per region per account. You can request an increase in the number of load balancers for your account.
- The service also makes it easy to add new instances or remove under-used instances when you need to increase or decrease the capacity of your application. The following diagram shows how the load balancer works. In this diagram, the load balancer contains two listeners. By default, the load balancer is configured to listen to HTTP traffic on port 80. The first listener accepts traffic on port 80 using HTTP and forwards these requests to the Amazon EC2 instances using HTTP on port 8080. The other listener accepts traffic on port 443 using HTTPS and forwards these requests to the Amazon EC2 instances using HTTPS on port 4443.

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# Creating and Verifying Elastic Load Balancer

- You can specify the protocol and port for both the client and the Amazon EC2 instances. In this step, we will create a load balancer for an HTTP service. We'll specify that the load balancer listens on port 80 for incoming traffic from clients and then distribute traffic on port 80 to the instances.

- As soon as your load balancer becomes available, you're billed for each hour or partial hour that you keep the load balancer running. For more information about Elastic Load Balancing pricing, see the Elastic Load Balancing details page. For more information about elastic load balancers, go to the Elastic Load Balancing Documentation.

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# Creating and Verifying Elastic Load Balancer

## Creating a Load Balancer

- You can create an internal load balancer to distribute traffic to your EC2 instances in private subnets.
- Load Balancer has two components: the load balancer and the controller service. The load balancer monitors traffic, whereas the controller service monitors load balancers.
- If a call is finished, a new load balancer is created with a unique Domain Name Service (DNS). Almost 20 load balancers can be created per account which is also extendable.

**1. Define a load balancer:**

- Open the Amazon EC2 console at https:// console.aws.amazon.com/ ec2/.
- In the Navigation pane, in the Region list, click US East (Virginia).
- In the Navigation pane, click Load balancers.
- In the Create a new load balancer wizard, in the load balancers pane, click create load balancers.
- On the define load balancer page, enter a name for your load balancer. In this example, type MyLB.
- create a new load balancer

- Leave the Listener Configuration set to the default value for this example. The Load Balancer Port and Protocol specify the port and protocol that the load balancer will use to listen for traffic from the clients. The Instance Protocol and Port specify the port and protocol the load balancer will use to route traffic to the instances. For example, if you want the load balancer to forward traffic to the instances using port 8080, you can specify that here.
- **Note:** After you configure the listener information, you cannot change it. If you want to update this information, you will need to create a new load balancer.

**Click Continue.**

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# Creating and Verifying Elastic Load Balancer

**2. Configure the Health Check:**

Elastic Load Balancing routinely checks the health of each load-balanced Amazon EC2 instance. This health check determines the instances of health status. If Elastic Load Balancing finds an unhealthy instance, it stops sending traffic to the instance and reroutes traffic to healthy instances.

a) On the Configure Health Check page of the **Create a New Load Balancer wizard**, do the following:

On the Configure Health Check page, under Configuration Options, do the following:

Leave Ping Protocol set to its default value of HTTP. In the future, if you want to use a more secure protocol for the load balancer to send ping requests to your instances, you can use HTTPS and specify a different port. For more information regarding HTTPS with Elastic Load Balancing, see Elastic Load Balancing Security Features in Elastic Load Balancing Developer Guide.

Leave Ping, Port set to its default value of 80. Elastic Load Balancing uses the ping port to send health check queries to your Amazon EC2 instances.

**Note:** If you specify a ping port value, your Amazon EC2 instances must accept incoming traffic on the port that you specify. You can set a port value other than 80, and you can change this value at any time.

In the Ping Path box, replace the default value with a single forward-slash (“/”).

Elastic Load Balancing sends health check queries to the ping path you specify. This example uses a single forward slash so that Elastic Load Balancing sends the query to your HTTP server’s default home page, whether that default page is named index.html, default.html, or any other different name. When you deploy your application, consider creating a special lightweight file that responds only to the health check. Doing so helps differentiate between traffic that is hitting your site and responses to the load balancer.

b) On the Configure Health Check page, under Advanced Options, set the Healthy Threshold to 2. Accept the default values on the other options. Typically, the default value of 10 is fine for a healthy threshold. To expedite this tutorial, we specify 2, so you don’t have to wait as long to see healthy instances.

c) Click Continue.

# Creating and Verifying Elastic Load Balancer

3. Add Amazon EC2 instances:
   - On the Add EC2 Instances page, click Continue.
   - Add Amazon EC2 instances

Review your settings. To make changes to the settings, click the edit link for a specific step in the process.
Add Amazon EC2 instances_2

Note: After you create a load balancer, you can modify any of the settings except for Load Balancer Name and Port Configuration. To rename a load balancer or to change its port configuration, create a replacement load balancer.

- Click Create.
- On the Confirmation page, click Close.

The confirmation window closes, returning you to the Load Balancers page. Your new load balancer now appears in the list.

As a best practice, you should have sufficient instances across Availability Zones to survive the loss of anyone Availability Zone. Therefore, we will ensure that our load balancer points to multiple Availability Zones in the next step.

# Creating and Verifying Elastic Load Balancer

**4. Record the Public DNS Address:**

- In the Load Balancers pane, click MyLB.
- Click the Description tab.
- Write down the public DNS address. You will need it later in this tutorial.

5. Add an Availability Zone:

- In the Load Balancers pane, click MyLB.
- Click the Instances tab.
- Click the plus icon.
- In the Add and Remove Availability Zones dialog box do the following:

Click us-east-1b: 0 instances.

Click us-east-1c: 0 instances.

Click Save.

In a later task, you will launch instances in these two Availability Zones by using Auto Scaling. You'll see that the Availability Zones column for the load balancer is updated for both Availability Zones.

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# Advantages of using Load Balancing

Elastic Load Balancing automatically distributes incoming application traffic across multiple Amazon EC2 instances in THE CLOUD.

It enables you to achieve greater levels of fault tolerance in your applications, seamlessly providing the required amount of load balancing capacity needed to distribute application traffic. Its most important benefits are available, secure, and elastic.

- Distribution of requests to EC2 instances in multiple availability zones
- Hazard of overloading of instances is minimized
- Continuous monitoring of health instances
- Support for the sticky session feature
- Support for end-to-end traffic encryption.

# Learning Resources

**Text books**


1. Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi, “Mastering Cloud Computing”, Tata McGraw Hill, ISBN-13: 978-1-25-02995-0
2. Tim Mather, Subra K, Shahid L, Cloud Security and Privacy, OReilly, ISBN-13 978-81-8404-815-5
3. Rajkumar Buyya, James Broberg, Andrzej Goscinski, “Cloud computing Principles and Paradigms”, Wiley Publication.
4. Barrie Sosinsky, “Cloud Computing", Wiley India, ISBN: 978-0-470-90356-8
5. Kailash Jayaswal, “Cloud computing", Black Book, Dreamtech Press
6. Thomas Erl, Zaigham Mahmood and Ricardo Puttini, “Cloud Computing: Concepts, Technology and Architecture”, Pearson, 1st Edition.


**Reference Books**


1. Introduction to the Theory of Computation, Michael Sipser.
2. Introduction to Languages and the Theory of Computation, John Martin.
3. Computers and Intractability: A Guide to the Theory of NP Completeness, M. R. Garey and D. S. Johnson


**Supplementary Reading:**


1. Dr. Kumar Saurabh, “Cloud Computing”, Wiley Publication

# Learning Resources

**Web Resources:**

i. https://www.ibm.com/cloud-computing/files/cloud-for-dummies.pdf

**Web links**

i. https://docs.aws.amazon.com/

ii. https://docs.microsoft.com/en-us/azure/

iii. https://tutorialsdojo.com/aws-elastic-load-balancing-elb/

**MOOCs:**

i. https://www.coursera.org/learn/gcp-fundamentals

ii. https://nptel.ac.in/courses/106105167/

# THANK YOU FOR LISTENING ANY QUESTION?