Prepare

Cloud Practitioner

CLF-C01

Yatharth Chauhan

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WELCOME TO PREPARE AWS CLOUD PRACTITIONER EXAM

AUTHOR: Yatharth Chauhan (Github: YatharthChauhan2362)
TOPIC: AWS Cloud Practitioner Exam Preparation

Table of contents

AWS Cloud Practitioner Preparation

- This will help you for quick revision before exam.
- If you are studying for AWS Cloud Practitioner certifications or you already have them but want to have digital notes of what you studied, here it is and you can come back as many times as you need. I share the notes I used to study and pass my exam.

Each Section contains a number of units. **Below Table Link** containing information about each sections in detail.

The AWS Certified Cloud Practitioner (CLF-C01) exam is intended for individuals who can effectively demonstrate an **overall knowledge of the AWS Cloud** independent of a specific job role. **The exam validates a candidate's ability to complete the following tasks:**

- Explain the value of the AWS Cloud
- Understand and explain the AWS shared responsibility model
- Understand security best practices
- Understand AWS Cloud costs, economics, and billing practices
- Describe and position the core AWS services, including compute, network, databases, and storage
- Identify AWS services for common use cases

Study Guide

Target candidate description

The target candidate should have 6 months, or the equivalent, of active engagement with the AWS Cloud, with exposure to AWS Cloud design, implementation, and/or operations. Candidates will demonstrate an understanding of well-designed AWS Cloud solutions.

Recommended AWS knowledge

The target candidate should have the following knowledge:

- AWS Cloud concepts
- Security and compliance within the AWS Cloud
- Understanding of the core AWS services
- Understanding of the economics of the AWS Cloud

What is considered out of scope for the target candidate?

The following is a non-exhaustive list of related job tasks that the target candidate is not expected to be able to perform.**These items are considered out of scope for the exam:**

- Coding
- Designing cloud architecture
- Troubleshooting
- Implementation
- Migration
- Load and performance testing

- Business applications (for example, Amazon Alexa, Amazon Chime, Amazon WorkMail)

Exam content

Response types

There are two types of questions on the exam:

- **Multiple choice:** Has one correct response and three incorrect responses.
- **Multiple response:** Has two or more correct responses out of five or more response options.

Unanswered questions are scored as incorrect; there is no penalty for guessing. The exam includes 50 questions that will affect your score.

Unscored content

The exam includes 15 unscored questions that do not affect your score. AWS collects information about candidate performance on these unscored questions to evaluate these questions for future use as scored questions. These unscored questions are not identified on the exam.

Exam results

The AWS Certified Cloud Practitioner exam is a pass or fail exam. The exam is scored against a minimum standard established by AWS professionals who follow certification industry best practices and guidelines.

Your results for the exam are reported as a scaled score of 100–1,000. The minimum passing score is 700. Your score shows how you performed on the exam as a whole and whether or not you passed. Scaled scoring models help equate scores across multiple exam forms that might have slightly different difficulty levels.

Your score report may contain a table of classifications of your performance at each section level. This information is intended to provide general feedback about your exam performance. The exam uses a compensatory scoring model, which means that **you do not need to achieve a passing score in each section.** You need to pass only the overall exam.

Each section of the exam has a specific weighting, so some sections have more questions than others. The table contains general information that highlights your strengths and weaknesses. Use caution when interpreting section-level feedback. Passing candidates will not receive this additional information.

Domain	% of Exam
Domain 1: Cloud Concepts	26%
Domain 2: Security and Compliance	25%
Domain 3: Technology	33%
Domain 4: Billing and Pricing	16%
TOTAL	**100%**

Domain 1: Cloud Concepts

Define the AWS Cloud and its value proposition

- Define the benefits of the AWS cloud including:
  - Security Reliability
  - High Availability
  - Elasticity
  - Agility
  - Pay-as-you go pricing
  - Scalability
  - Global Reach
  - Economy of scale
- Explain how the AWS cloud allows users to focus on business value:
  - Shifting technical resources to revenue-generating activities as opposed to managing infrastructure

Identify aspects of AWS Cloud economics

- Define items that would be part of a Total Cost of Ownership proposal:
  - Understand the role of operational expenses (OpEx)
  - Understand the role of capital expenses (CapEx)
  - Understand labor costs associated with on-premises operations
  - Understand the impact of software licensing costs when moving to the cloud
- Identify which operations will reduce costs by moving to the cloud:
- Right-sized infrastructure
- Benefits of automation
- Reduce compliance scope (for example, reporting)
- Managed services (for example, RDS, ECS, EKS, DynamoDB)

Explain the different cloud architecture design principles

- Explain the design principles:
  - Design for failure
  - Decouple components versus monolithic architecture
  - Implement elasticity in the cloud versus on-premises
  - Think parallel

Domain 2: Security and Compliance

Define the AWS shared responsibility model

- Recognize the elements of the Shared Responsibility Model
- Describe the customer's responsibly on AWS:
  - Describe how the customer's responsibilities may shift depending on the service used (for example with RDS, Lambda, or EC2)
- Describe AWS responsibilities

Define AWS Cloud security and compliance concepts

- Identify where to find AWS compliance information:

    - Locations of lists of recognized available compliance controls (for example, HIPPA, SOCs)
    - Recognize that compliance requirements vary among AWS services
- At a high level, describe how customers achieve compliance on AWS:
    - Identify different encryption options on AWS (for example, In transit, At rest)
- Describe who enables encryption on AWS for a given service
- Recognize there are services that will aid in auditing and reporting:
    - Recognize that logs exist for auditing and monitoring (do not have to understand the logs)
    - Define Amazon CloudWatch, AWS Config, and AWS CloudTrail
- Explain the concept of least privileged access

Identify AWS access management capabilities

- Understand the purpose of User and Identity Management
    - Access keys and password policies (rotation, complexity)
    - Multi-Factor Authentication (MFA)
    - AWS Identity and Access Management (IAM)
        - Groups/users
        - Roles
        - Policies, managed policies compared to custom policies
    - Tasks that require use of root accounts
    - Protection of root accounts

Identify resources for security support

- Recognize there are different network security capabilities
    - Native AWS services (for example, security groups, Network ACLs, AWS WAF)
    - 3rd party security products from the AWS Marketplace
- Recognize there is documentation and where to find it (for example, best practices, whitepapers, official documents)
    - AWS Knowledge Center, Security Center, security forum, and security blogs
- Partner Systems Integrators
- Know that security checks are a component of AWS Trusted Advisor

Domain 3: Technology

Define methods of deploying and operating in the AWS Cloud

- Identify at a high level different ways of provisioning and operating in the AWS cloud:
    - Programmatic access, APIs, SDKs, AWS Management Console, CLI, Infrastructure as Code
- Identify different types of cloud deployment models:
    - All in with cloud/cloud native
    - Hybrid
    - On-premises
- Identify connectivity options
    - VPN
    - AWS Direct Connect
    - Public internet

Define the AWS global infrastructure

- Describe the relationships among Regions, Availability Zones, and Edge Locations
- Describe how to achieve high availability through the use of multiple Availability Zones:
    - Recall that high availability is achieved by using multiple Availability Zones
    - Recognize that Availability Zones do not share single points of failure
- Describe when to consider the use of multiple AWS Regions:
    - Disaster recovery/business continuity
    - Low latency for end-users
    - Data sovereignty
- Describe at a high level the benefits of Edge Locations
    - Amazon CloudFront
    - AWS Global Accelerator

Identify the core AWS services

- Describe the categories of services on AWS (compute, storage, network, database)
- Identify AWS compute services:
    - Recognize there are different compute families
    - Recognize the different services that provide compute (for example, AWS Lambda compared to Amazon Elastic Container Service (Amazon ECS), or Amazon EC2, etc.)
    - Recognize that elasticity is achieved through Auto Scaling
    - Identify the purpose of load balancers
- Identify different AWS storage services:
    - Describe Amazon S3
    - Describe Amazon Elastic Block Store (Amazon EBS)
    - Describe Amazon S3 Glacier
    - Describe AWS Snowball
    - Describe Amazon Elastic File System (Amazon EFS)
    - Describe AWS Storage Gateway
    - Identify AWS networking services
    - Identify VPC
    - Identify security groups
    - Identify the purpose of Amazon Route 53
    - Identify VPN, AWS Direct Connect
- Identify different AWS database services:
    - Install databases on Amazon EC2 compared to AWS managed databases
    - Identify Amazon RDS
    - Identify Amazon DynamoDB
    - Identify Amazon Redshift

Identify resources for technology support

- Recognize there is documentation (best practices, whitepapers, AWS Knowledge Center, forums, blogs)
- Identify the various levels and scope of AWS support:
    - AWS Abuse
    - AWS support cases
    - Premium support

    - Technical Account Managers
- Recognize there is a partner network (marketplace, third-party) including Independent Software Vendors and System Integrators
- Identify sources of AWS technical assistance and knowledge including professional services, solution architects, training and certification, and the Amazon Partner Network
- Identify the benefits of using AWS Trusted Advisor

Domain 4: Billing and Pricing

Compare and contrast the various pricing models for AWS (for example, On-Demand Instances, Reserved Instances, and Spot Instance pricing)

- Identify scenarios/best fit for On-Demand Instance pricing
- Identify scenarios/best fit for Reserved-Instance pricing:
    - Describe Reserved-Instances flexibility
    - Describe Reserved-Instances behavior in AWS Organizations
- Identify scenarios/best fit for Spot Instance pricing

Recognize the various account structures in relation to AWS billing and pricing

- Recognize that consolidated billing is a feature of AWS Organizations
- Identify how multiple accounts aid in allocating costs across departments

Identify resources available for billing support

- Identify ways to get billing support and information:
    - Cost Explorer, AWS Cost and Usage Report, Amazon QuickSight, third-party partners, and AWS Marketplace tools
    - Open a billing support case
    - The role of the Concierge for AWS Enterprise Support Plan customers
- Identify where to find pricing information on AWS services:
    - AWS Simple Monthly Calculator
    - AWS Services product pages
    - AWS Pricing API
- Recognize that alarms/alerts exist
- Identify how tags are used in cost allocation

AWS Official Guide Reference Link:

- AWS Official Website
- AWS Reference PDF

Cloud Computing Fundamentals

- What is Cloud Computing?
    - The Deployment Models of the Cloud
    - The Five Characteristics of Cloud Computing
    - Six Advantages of Cloud Computing
    - Problems solved by the Cloud

What is Cloud Computing?

- Cloud computing is the on-demand delivery of compute power, database storage, applications, and other IT resources
- Through a cloud services platform with pay-as-you-go pricing
- You can provision exactly the right type and size of computing resources you need
- You can access as many resources as you need, almost instantly
- Simple way to access servers, storage, databases and a set of application services
- Amazon Web Services owns and maintains the network-connected hardware required for these application services, while you provision and use what you need via a web application.

The Deployment Models of the Cloud

Private Cloud:	**Public Cloud:**	**Hybrid Cloud:**
Cloud services used by a single organization, not exposed to the public.	Cloud resources owned and operated by a thirdparty cloud service provider delivered over the Internet.	Keep some servers on premises and extend some capabilities to the Cloud
Complete control	Six Advantages of Cloud Computing	Control over sensitive assets in your private infrastructure
Security for sensitive applications		Flexibility and costeffectiveness of the public cloud
Meet specific business needs		

The Five Characteristics of Cloud Computing

- **On-demand self service:**
    - Users can provision resources and use them without human interaction from the service provider
- **Broad network access:**
    - Resources available over the network, and can be accessed by diverse client platforms
- **Multi-tenancy and resource pooling:**
    - Multiple customers can share the same infrastructure and applications with security and privacy

    - Multiple customers are serviced from the same physical resources
- **Rapid elasticity and scalability:**
    - Automatically and quickly acquire and dispose resources when needed
    - Quickly and easily scale based on demand
- **Measured service:**
    - Usage is measured, users pay correctly for what they have used

Six Advantages of Cloud Computing

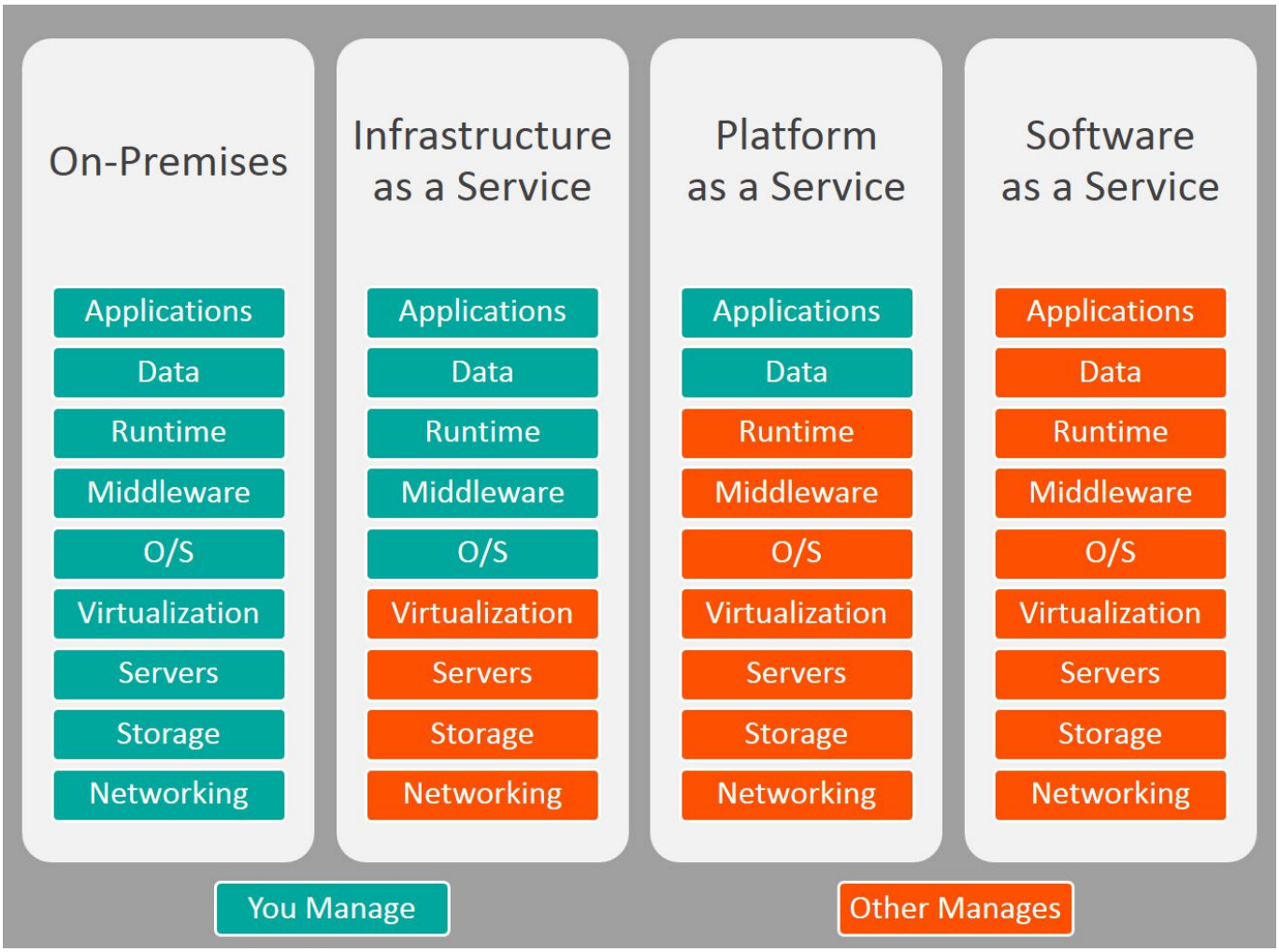
- **Trade capital expense (CAPEX) for operational expense (OPEX)**
    - Pay On-Demand: don't own hardware
    - Reduced Total Cost of Ownership (TCO) & Operational Expense (OPEX)
- **Benefit from massive economies of scale**
    - Prices are reduced as AWS is more efficient due to large scale
- **Stop guessing capacity**
    - Scale based on actual measured usage
- **Increase speed and agility**
- **Stop spending money running and maintaining data centers**
- **Go global in minutes:** leverage the AWS global infrastructure

Problems solved by the Cloud

- **Flexibility:** change resource types when needed
- **Cost-Effectiveness:** pay as you go, for what you use
- **Scalability:** accommodate larger loads by making hardware stronger or adding additional nodes
- **Elasticity:** ability to scale out and scale-in when needed
- **High-availability and fault-tolerance:** build across data centers
- **Agility:** rapidly develop, test and launch software applications

Types of Cloud Computing

- **Infrastructure as a Service (IaaS)**
    - Provide building blocks for cloud IT
    - Provides networking, computers, data storage space
    - Highest level of flexibility
    - Easy parallel with traditional on-premises IT
- **Platform as a Service (PaaS)**
    - Removes the need for your organization to manage the underlying infrastructure
    - Focus on the deployment and management of your applications
- **Software as a Service (SaaS)**
    - Completed product that is run and managed by the service provider



Example of Cloud Computing Types

- **Infrastructure as a Service:**
  - Amazon EC2 (on AWS)
  - GCP, Azure, Rackspace, Digital Ocean, Linode
- Platform as a Service:
  - Elastic Beanstalk (on AWS)
  - Heroku, Google App Engine (GCP), Windows Azure (Microsoft)
- Software as a Service:
  - Many AWS services (ex: Rekognition for Machine Learning)
  - Google Apps (Gmail), Dropbox, Zoom

Pricing of the Cloud – Quick Overview

- AWS has 3 pricing fundamentals, following the pay-as-you-go pricing model
- **Compute:**
  - Pay for compute time
- **Storage:**
  - Pay for data stored in the Cloud
- **Data transfer OUT of the Cloud:**
  - Data transfer IN is free
- Solves the expensive issue of traditional IT

AWS Cloud Use Cases

- AWS enables you to build sophisticated, scalable applications
- Applicable to a diverse set of industries
- Use cases include
    - Enterprise IT, Backup & Storage, Big Data analytics
    - Website hosting, Mobile & Social Apps
    - Gaming

AWS Global Infrastructure

- AWS Regions
- AWS Availability Zones
- AWS Data Centers
- AWS Edge Locations / Points of Presence
- https://infrastructure.aws/

AWS Regions

- AWS has Regions all around the world
- Names can be us-east-1, eu-west-3…
- A region is a **cluster of data centers**
- **Most AWS services are region-scoped**

How to choose an AWS Region?

If you need to launch a new application, where should you do it?

- **Compliance with data governance and legal requirements:** data never leaves a region without your explicit permission
- **Proximity to customers:** reduced latency
- **Available services within a Region:** new services and new features aren’t available in every Region
- **Pricing:** pricing varies region to region and is transparent in the service pricing page

AWS Availability Zones

- Each region has many availability zones (usually 3, min is 2, max is 6). Example:
    - ap-southeast-2a
    - ap-southeast-2b
    - ap-southeast-2c
- Each availability zone (AZ) is one or more discrete data centers with redundant power, networking, and connectivity
- They’re separate from each other, so that they’re isolated from disasters
- They’re connected with high bandwidth, ultra-low latency networking

AWS Points of Presence (Edge Locations)

- Amazon has 216 Points of Presence (205 Edge Locations & 11 Regional Caches) in 84 cities across 42 countries

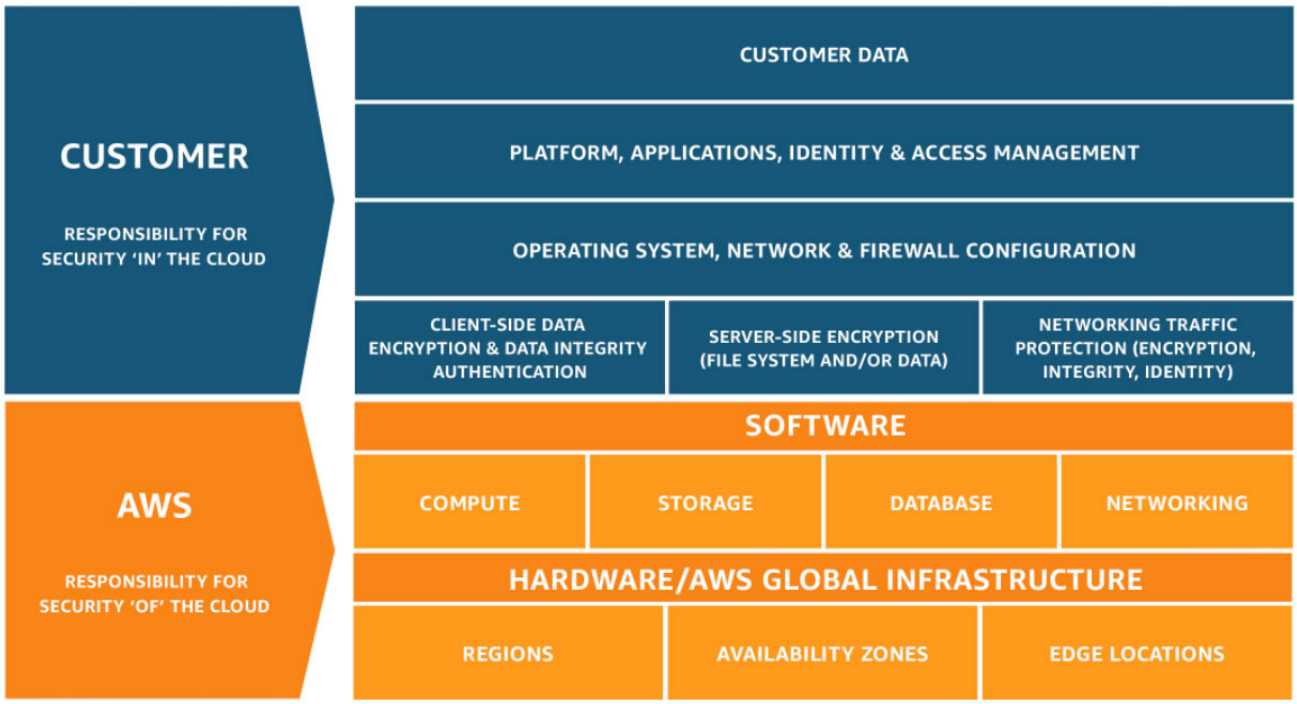
- Content is delivered to end users with lower latency

Tour of the AWS Console

- **AWS has Global Services:**
  - Identity and Access Management (IAM)
  - Route 53 (DNS service)
  - CloudFront (Content Delivery Network)
  - WAF (Web Application Firewall)
- **Most AWS services are Region-scoped:**
  - Amazon EC2 (Infrastructure as a Service)
  - Elastic Beanstalk (Platform as a Service)
  - Lambda (Function as a Service)
  - Rekognition (Software as a Service)
- **Region Table:** https://aws.amazon.com/about-aws/global-infrastructure/regional-product-services

Shared Responsibility Model

- CUSTOMER = RESPONSIBILITY FOR THE SECURITY **IN** THE CLOUD
- AWS = RESPONSIBILITY FOR THE SECURITY **OF** THE CLOUD



IAM: Identity Access and Management

What Is IAM?

AWS Identity and Access Management (IAM) is a web service that helps you securely control access to AWS resources. You use IAM to control who is authenticated (signed in) and authorized (has permissions) to use resources.

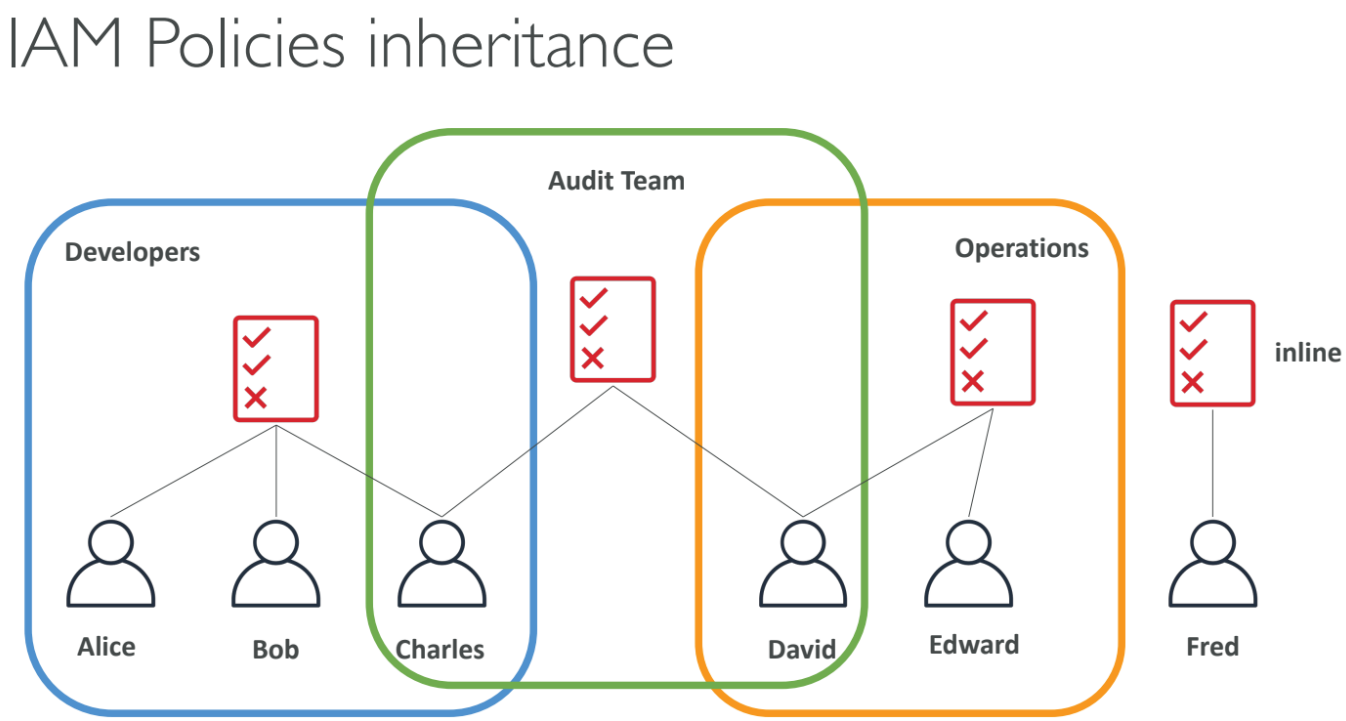
IAM: Users & Groups

- IAM = Identity and Access Management, Global service
- **Root account** created by default, shouldn't be used or shared
- **Users** are people within your organization, and can be grouped
- **Groups** only contain users, not other groups
- Users don't have to belong to a group, and user can belong to multiple groups

IAM: Permissions

- Users or Groups can be assigned JSON documents called policies
- These policies define the permissions of the users
- In AWS you apply the least privilege principle: don't give more permissions than a user needs

IAM Policies Inheritance



IAM Policies Structure

- Consists of
  - Version: policy language version, always include "2012-10-17"
  - Id: an identifier for the policy (optional)
  - Statement: one or more individual statements (required)
- Statements consists of
  - Sid: an identifier for the statement (optional)
  - Effect: whether the statement allows or denies access (Allow, Deny)
  - Principal: account/user/role to which this policy applied to
  - Action: list of actions this policy allows or denies
  - Resource: list of resources to which the actions applied to
  - Condition: conditions for when this policy is in effect (optional)

Example:

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "Effect": "Allow",
      "Action": "ec2:Describe*",
      "Resource": "*"
    },
    {
      "Effect": "Allow",
      "Action": "elasticloadbalancing:Describe*",
      "Resource": "*"
    },
    {
      "Effect": "Allow",
      "Action": [
        "cloudwatch:ListMetrics",
        "cloudwatch:GetMetricStatistics",
        "cloudwatch:Describe*"
      ],
      "Resource": "*"
    }
  ]
}
```

IAM – Password Policy

- Strong passwords = higher security for your account
- In AWS, you can setup a password policy:
  - Set a minimum password length
  - Require specific character types:
    - including uppercase letters
    - lowercase letters
    - numbers
    - non-alphanumeric characters
- Allow all IAM users to change their own passwords
- Require users to change their password after some time (password expiration)
- Prevent password re-use

IAM Roles for Services

- Some AWS service will need to perform actions on your behalf
- To do so, we will assign permissions to AWS services with IAM Roles
- Common roles:
  - EC2 Instance Roles
  - Lambda Function Roles
  - Roles for CloudFormation

IAM Security Tools

- IAM Credentials Report (account-level)
- a report that lists all your account's users and the status of their various credentials
- IAM Access Advisor (user-level)
- Access advisor shows the service permissions granted to a user and when those services were last accessed.
- You can use this information to revise your policies.

IAM Guidelines & Best Practices

- Don’t use the root account except for AWS account setup
- One physical user = One AWS user
- **Assign users to groups** and assign permissions to groups
- Create a **strong password policy**
- Use and enforce the use of **Multi Factor Authentication (MFA)**
- Create and use Roles for giving permissions to AWS services
- Use Access Keys for Programmatic Access (CLI / SDK)
- Audit permissions of your account with the IAM Credentials Report
- **Never share IAM users & Access Keys**

Shared Responsibility Model for IAM

AWS	YOU
Infrastructure (global network security)	Users, Groups, Roles, Policies management and monitoring
Configuration and vulnerability analysis	Enable MFA on all accounts
Compliance validation	Rotate all your keys often, Use IAM tools to apply appropriate permissions, Analyze access patterns & review permissions

Multi Factor Authentication - MFA

- Users have access to your account and can possibly change configurations or delete resources in your AWS account
- You want to protect your Root Accounts and IAM users
- MFA = password you know + security device you own
- Main benefit of MFA: if a password is stolen or hacked, the account is not compromised

MFA devices options in AWS

- Virtual MFA device (Support for multiple tokens on a single device.)
  - Google Authenticator (phone only)
  - Authy (multi-device)
- Universal 2nd Factor (U2F) Security Key (Support for multiple root and IAM users using a single security key)
  - YubiKey by Yubico (3rd party)
- Hardware Key Fob MFA Device

- Hardware Key Fob MFA Device for AWS GovCloud (US)

How can users access AWS ?

- To access AWS, you have three options:
  - AWS Management Console (protected by password + MFA)
  - AWS Command Line Interface (CLI): protected by access keys
  - AWS Software Developer Kit (SDK) - for code: protected by access keys
- Access Keys are generated through the AWS Console
- Users manage their own access keys
- Access Keys are secret, just like a password. Don't share them
- Access Key ID ~= username
- Secret Access Key ~= password

What's the AWS CLI?

- A tool that enables you to interact with AWS services using commands in your command-line shell
- Direct access to the public APIs of AWS services
- You can develop scripts to manage your resources
- It's open-source https://github.com/aws/aws-cli
- Alternative to using AWS Management Console

What's the AWS SDK?

- AWS Software Development Kit (AWS SDK)
- Language-specific APIs (set of libraries)
- Enables you to access and manage AWS services programmatically
- Embedded within your application
- Supports
  - SDKs (JavaScript, Python, PHP, .NET, Ruby, Java, Go, Node.js, C++)
  - Mobile SDKs (Android, iOS, ...)
  - IoT Device SDKs (Embedded C, Arduino, ...)
- Example: AWS CLI is built on AWS SDK for Python

IAM Section – Summary

- **Users:** mapped to a physical user, has a password for AWS Console
- **Groups:** contains users only
- **Policies:** JSON document that outlines permissions for users or groups
- **Roles:** for EC2 instances or AWS services
- **Security:** MFA + Password Policy
- **AWS CLI:** manage your AWS services using the command-line
- **AWS SDK:** manage your AWS services using a programming language
- **Access Keys:** access AWS using the CLI or SDK
- **Audit:** IAM Credential Reports & IAM Access Advisor

EC2: Virtual Machines

What is Amazon EC2?

Amazon Elastic Compute Cloud (Amazon EC2) provides scalable computing capacity in the Amazon Web Services (AWS) Cloud.

- EC2 is one of the most popular of AWS' offering
- EC2 = Elastic Compute Cloud = Infrastructure as a Service
- It mainly consists in the capability of :
  - Renting virtual machines (EC2)
  - Storing data on virtual drives (EBS)
  - Distributing load across machines (ELB)
  - Scaling the services using an auto-scaling group (ASG)
- Knowing EC2 is fundamental to understand how the Cloud works

EC2 sizing & configuration options

- Operating System (OS): Linux, Windows or Mac OS
- How much compute power & cores (CPU)
- How much random-access memory (RAM)

- How much storage space:
  - Network-attached (EBS & EFS)
  - hardware (EC2 Instance Store)
- Network card: speed of the card, Public IP address
- Firewall rules: **security group**
- Bootstrap script (configure at first launch): EC2 User Data

EC2 User Data

- It is possible to bootstrap our instances using an **EC2 User data** script.
- **bootstrapping** means launching commands when a machine starts
- That script is **only run once** at the instance **first start**
- EC2 user data is used to automate boot tasks such as:
  - Installing updates
  - Installing software
  - Downloading common files from the internet
  - Anything you can think of
- The EC2 User Data Script runs with the root user

EC2 Instance Types - Overview

- You can use different types of EC2 instances that are optimised for different use cases (https://aws.amazon.com/ec2/instance-types/)
  - General Purpose
  - Compute Optimized
  - Memory Optimized
  - Storage Optimized
  - Accelerated Computing
- AWS has the following naming convention: m5.2xlarge
- m: instance class
- 5: generation (AWS improves them over time)
- 2xlarge: size within the instance class

General Purpose

- Great for a diversity of workloads such as web servers or code repositories
- Balance between:
  - Compute
  - Memory
  - Networking

Compute Optimized

- Great for compute-intensive tasks that require high performance processors:
  - Batch processing workloads

- Media transcoding
- High performance web servers
- High performance computing (HPC)
- Scientific modeling & machine learning
- Dedicated gaming servers

Memory Optimized

- Fast performance for workloads that process large data sets in memory
- Use cases:
  - High performance, relational/non-relational databases
  - Distributed web scale cache stores
  - In-memory databases optimized for BI (business intelligence)
  - Applications performing real-time processing of big unstructured data

Storage Optimized

- Great for storage-intensive tasks that require high, sequential read and write access to large data sets on local storage
- Use cases:
  - High frequency online transaction processing (OLTP) systems
  - Relational & NoSQL databases
  - Cache for in-memory databases (for example, Redis)
  - Data warehousing applications
  - Distributed file systems

EC2 Instance Types: example

Instance	vCPU	Mem (GiB)	Storage	Network Performance	EBS Bandwidth (Mbps)
t2.micro	1	1	EBS-Only	Low to Moderate	
t2.xlarge	4	16	EBS-Only	Moderate	
c5d.4xlarge	16	32	1 x 400 NVMe SSD	Up to 10 Gbps	4,750
r5.16xlarge	64	512	EBS Only	20 Gbps	13,600
m5.8xlarge	32	128	EBS Only	10 Gbps	6,800

t2.micro is part of the AWS free tier (up to 750 hours per month)

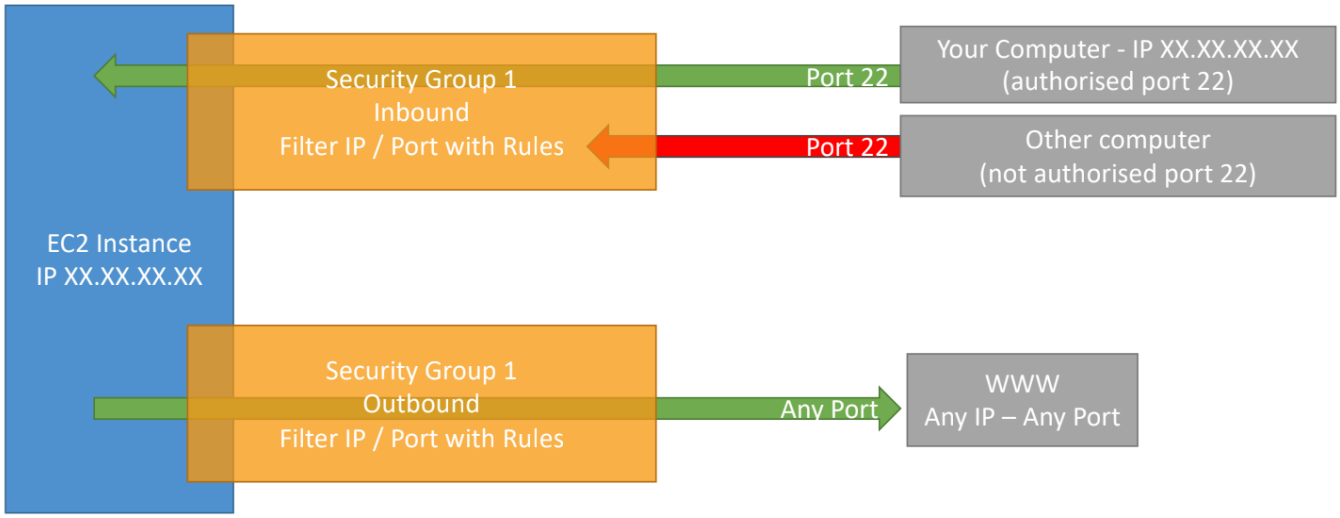
Introduction to Security Groups

- Security Groups are the fundamental of network security in AWS
- They control how traffic is allowed into or out of our EC2 Instances.
- Security groups only contain allow rules
- Security groups rules can reference by IP or by security group

Deeper Dive

- Security groups are acting as a “firewall” on EC2 instances
- They regulate:
  - Access to Ports
  - Authorised IP ranges – IPv4 and IPv6
  - Control of inbound network (from other to the instance)
  - Control of outbound network (from the instance to other)

Security Groups Diagram



Good to know

- Can be attached to multiple instances
- Locked down to a region / VPC combination
- Does live “outside” the EC2 – if traffic is blocked the EC2 instance won’t see it
- It’s good to maintain one separate security group for SSH access
- If your application is not accessible (time out), then it’s a security group issue
- If your application gives a “connection refused” error, then it’s an application error or it’s not launched
- All inbound traffic is **blocked** by default
- All outbound traffic is **authorized** by default

Classic Ports to know

- 22 = SSH (Secure Shell) - log into a Linux instance
- 21 = FTP (File Transfer Protocol) – upload files into a file share
- 22 = SFTP (Secure File Transfer Protocol) – upload files using SSH
- 80 = HTTP – access unsecured websites
- 443 = HTTPS – access secured websites
- 3389 = RDP (Remote Desktop Protocol) – log into a Windows instance

EC2 Instance Launch Types

- **On Demand Instances**: short workload, predictable pricing
- **Reserved**: (1 & 3 years)

    - **Reserved Instances**: long workloads
    - **Convertible Reserved Instances**: long workloads with flexible instances
- **Savings Plans** (1 & 3 years): commitment to an amount of usage, long workload
- **Spot Instances**: short workloads, for cheap, can lose instances
- **Dedicated Instances**: no other customers will share your hardware
- **Dedicated Hosts**: book an entire physical server, control instance placement
- **Capacity Reservations**: reserve capacity in a specific AZ for any duration

On Demand Instance

- Pay for what you use:
    - Linux or Windows - billing per second, after the first minute
    - All other operating systems - billing per hour
- Has the highest cost but no upfront payment
- No long-term commitment
- Recommended for **short-term** and **un-interrupted workloads**, where you can't predict how the application will behave

Reserved Instances

- Up to 72% discount compared to On-demand
- You reserve a specific instance attributes (Instance Type, Region, Tenancy, OS)
- Reservation Period – 1 year (+discount) or 3 years (+++discount)
- Payment Options – No Upfront (+), Partial Upfront (++), All Upfront (+++)
- Reserved Instance's Scope – Regional or Zonal (reserve capacity in an AZ)
- Recommended for steady-state usage applications (think database)
- You can buy and sell in the Reserved Instance Marketplace
- Convertible Reserved Instance
    - Can change the EC2 instance type, instance family, OS, scope and tenancy
    - Up to 66% discount

Savings Plans

- Get a discount based on long-term usage (up to 72% - same as RIs)
- Commit to a certain type of usage ($10/hour for 1 or 3 years)
- Usage beyond EC2 Savings Plans is billed at the On-Demand price
- Locked to a specific instance family & AWS region (e.g., M5 in us-east-1)
- Flexible across:
    - Instance Size (e.g., m5.xlarge, m5.2xlarge)
    - OS (e.g., Linux, Windows)

    - Tenancy (Host, Dedicated, Default)

Spot Instances

- Can get a discount of up to 90% compared to On-demand
- Instances that you can "lose" at any point of time if your max price is less than the current spot price
- The MOST cost-efficient instances in AWS
- Useful for workloads that are resilient to failure
    - Batch jobs
    - Data analysis
    - Image processing
    - Any distributed workloads
    - Workloads with a flexible start and end time
- Not suitable for critical jobs or databases

Dedicated Hosts

- A physical server with EC2 instance capacity fully dedicated to your use
- Allows you address compliance requirements and use your existing server- bound software licenses (per-socket, per-core, pe—VM software licenses)
- Purchasing Options:
    - On-demand – pay per second for active Dedicated Host
    - Reserved - 1 or 3 years (No Upfront, Partial Upfront, All Upfront)
- The most expensive option
- Useful for software that have complicated licensing model (BYOL – Bring Your Own License)
- Or for companies that have strong regulatory or compliance needs

Dedicated Instances

- Instances run on hardware that's dedicated to you
- May share hardware with other instances in same account
- No control over instance placement (can move hardware after Stop / Start)

Capacity Reservations

- Reserve On-Demand instances capacity in a specific AZ for any duration
- You always have access to EC2 capacity when you need it
- No time commitment (create/cancel anytime), no billing discounts
- Combine with Regional Reserved Instances and Savings Plans to benefit from billing discounts
- You're charged at On-Demand rate whether you run instances or not
- Suitable for short-term, uninterrupted workloads that needs to be in a specific AZ

Which purchasing option is right for me?

- On demand: coming and staying in resort whenever we like, we pay the full price
- Reserved: like planning ahead and if we plan to stay for a long time, we may get a good discount.
- Savings Plans: pay a certain amount per hour for certain period and stay in any room type (e.g., King, Suite, Sea View, ...)

- Spot instances: the hotel allows people to bid for the empty rooms and the highest bidder keeps the rooms. You can get kicked out at any time
- Dedicated Hosts: We book an entire building of the resort
- Capacity Reservations: you book a room for a period with full price even you don't stay in it

Price Comparison Example – m4.large – us-east-1

Price Type	Price (per hour)
On-Demand	$0.10
Spot Instance (Spot Price)	$0.038 - $0.039 (up to 61% off)
Reserved Instance (1 year)	$0.062 (No Upfront) - $0.058 (All Upfront)
Reserved Instance (3 years)	$0.043 (No Upfront) - $0.037 (All Upfront)
EC2 Savings Plan (1 year)	$0.062 (No Upfront) - $0.058 (All Upfront)
Reserved Convertible Instance (1 year)	$0.071 (No Upfront) - $0.066 (All Upfront)
Dedicated Host	On-Demand Price
Dedicated Host Reservation	Up to 70% off
Capacity Reservations	On-Demand Price

Shared Responsibility Model for EC2

AWS	USER
Infrastructure (global network security)	Security Groups rules
Isolation on physical hosts	Operating-system patches and updates
Replacing faulty hardware	Software and utilities installed on the EC2 instance
Compliance validation	IAM Roles assigned to EC2 & IAM user access management, Data security on your instance

EC2 Section – Summary

- EC2 Instance: AMI (OS) + Instance Size (CPU + RAM) + Storage + security groups + EC2 User Data
- Security Groups: Firewall attached to the EC2 instance
- EC2 User Data: Script launched at the first start of an instance
- SSH: start a terminal into our EC2 Instances (port 22)
- EC2 Instance Role: link to IAM roles
- Purchasing Options: On-Demand, Spot, Reserved (Standard + Convertible + Scheduled), Dedicated Host, Dedicated Instance

EC2 Instance Storage

- EBS: Elastic Block Store, Volume is a network drive you can attach to your instances while they run
- EFS: network file system, can be attached to 100s of instances in a region
- EFS-IA: cost-optimized storage class for infrequent accessed files
- FSx for Windows: Network File System for Windows servers
- FSx for Lustre: High Performance Computing Linux file system

EBS Volumes

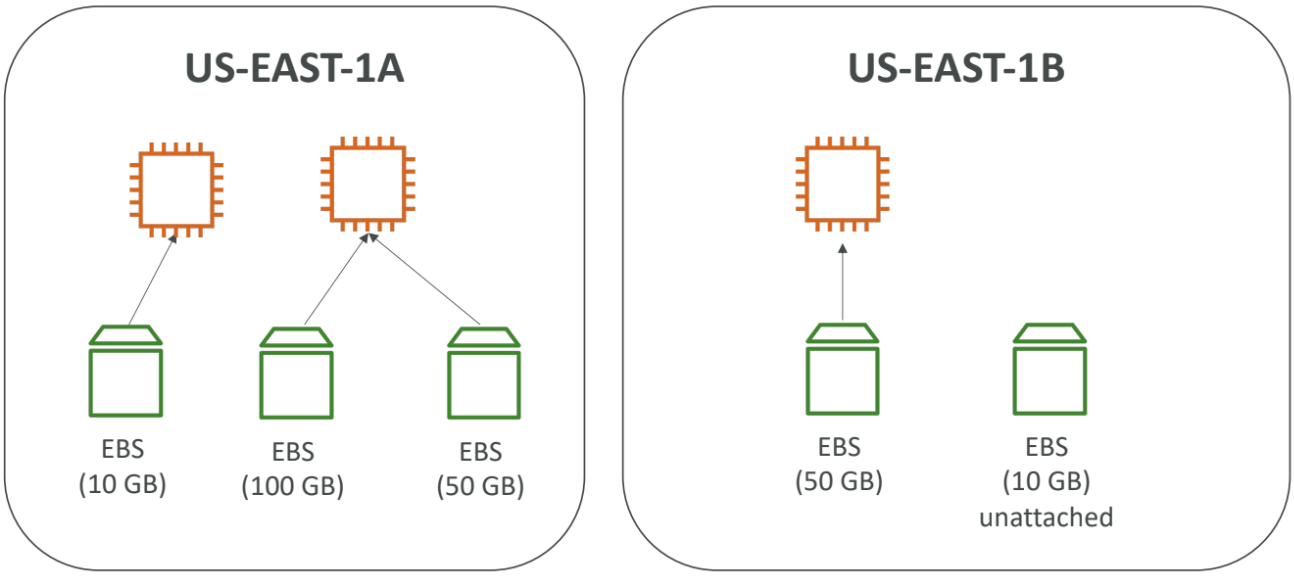
What's an EBS Volume?

- An EBS (Elastic Block Store) Volume is a network drive you can attach to your instances while they run
- It allows your instances to persist data, even after their termination
- They can only be mounted to one instance at a time (at the CCP level)
- They are bound to a specific availability zone
- Analogy: Think of them as a "network USB stick"
- Free tier: 30 GB of free EBS storage of type General Purpose (SSD) or Magnetic per month

EBS Volume

- It's a network drive (i.e. not a physical drive)
    - It uses the network to communicate the instance, which means there might be a bit of latency
    - It can be detached from an EC2 instance and attached to another one quickly
- It's locked to an Availability Zone (AZ)
    - An EBS Volume in us-east-1a cannot be attached to us-east-1b
    - To move a volume across, you first need to snapshot it
- Have a provisioned capacity (size in GBs, and IOPS)
    - You get billed for all the provisioned capacity

- You can increase the capacity of the drive over time



EBS – Delete on Termination attribute

- Controls the EBS behaviour when an EC2 instance terminates
  - By default, the root EBS volume is deleted (attribute enabled)
  - By default, any other attached EBS volume is not deleted (attribute disabled)
- This can be controlled by the AWS console / AWS CLI
- Use case: preserve root volume when instance is terminated

EBS Snapshots

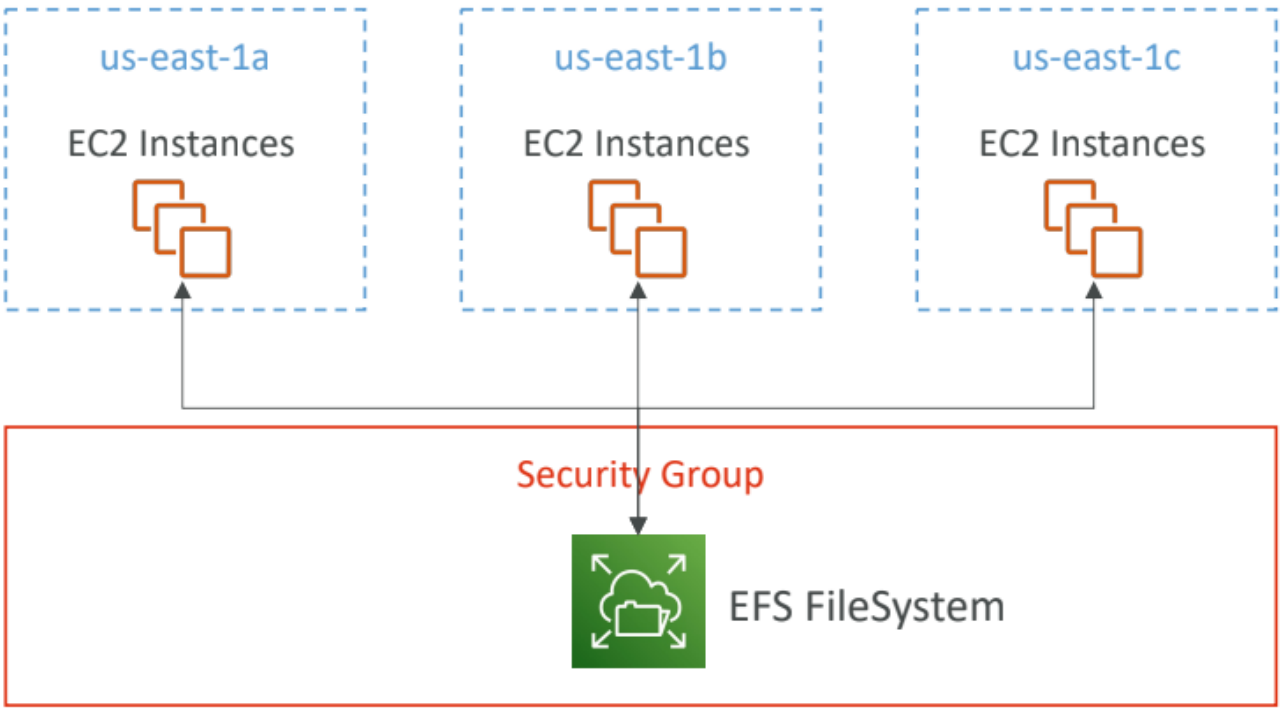
- Make a backup (snapshot) of your EBS volume at a point in time
- Not necessary to detach volume to do snapshot, but recommended
- Can copy snapshots across AZ or Region

EBS Snapshots Features

- EBS Snapshot Archive
  - Move a Snapshot to an "archive tier" that is 75% cheaper
  - Takes within 24 to 72 hours for restoring the archive
- Recycle Bin for EBS Snapshots
  - Setup rules to retain deleted snapshots so you can recover them after an accidental deletion
  - Specify retention (from 1 day to 1 year)

EFS: Elastic File System

- Managed NFS (network file system) that can be mounted on 100s of EC2
- EFS works with **Linux** EC2 instances in **multi-AZ**
- Highly available, scalable, expensive (3x gp2), pay per use, no capacity planning



EFS Infrequent Access (EFS-IA)

- Storage class that is cost-optimized for files not accessed every day
- Up to 92% lower cost compared to EFS Standard
- EFS will automatically move your files to EFS-IA based on the last time they were accessed
- Enable EFS-IA with a Lifecycle Policy
- Example: move files that are not accessed for 60 days to EFS-IA
- Transparent to the applications accessing EFS

Amazon FSx – Overview

- Launch 3rd party high-performance file systems on AWS
- Fully managed service
  - FSx for Lustre
  - FSx for Windows File Server
  - FSx for NetApp ONTAP

Amazon FSx for Windows File Server

- A fully managed, highly reliable, and scalable Windows native shared file system
- Built on Windows File Server
- Supports SMB protocol & Windows NTFS
- Integrated with Microsoft Active Directory
- Can be accessed from AWS or your on-premise infrastructure

Amazon FSx for Lustre

- A fully managed, high-performance, scalable file storage for High Performance Computing (HPC)
- The name Lustre is derived from “Linux” and “cluster”
- Machine Learning, Analytics, Video Processing, Financial Modeling

- Scales up to 100s GB/s, millions of IOPS, sub-ms latencies

EC2 Instance Store

- EBS volumes are network drives with good but “limited” performance
- If you need a high-performance hardware disk, use EC2 Instance Store
- Better I/O performance
- EC2 Instance Store lose their storage if they’re stopped (ephemeral)
- Good for buffer / cache / scratch data / temporary content
- Risk of data loss if hardware fails
- Backups and Replication are your responsibility

Shared Responsibility Model for EC2 Storage

AWS	USER
Infrastructure	Setting up backup / snapshot procedures
Replication for data for EBS volumes & EFS drives	Setting up data encryption
Replacing faulty hardware	Responsibility of any data on the drives
Ensuring their employees cannot access your data	Understanding the risk of using EC2 Instance Store

AMI Overview

- AMI = Amazon Machine Image
- AMI are a customization of an EC2 instance
  - You add your own software, configuration, operating system, monitoring…
  - Faster boot / configuration time because all your software is pre-packaged
- AMI are built for a specific region (and can be copied across regions)
- You can launch EC2 instances from:
  - A Public AMI: AWS provided
  - Your own AMI: you make and maintain them yourself
  - An AWS Marketplace AMI: an AMI someone else made (and potentially sells)

AMI Process (from an EC2 instance)

- Start an EC2 instance and customize it
- Stop the instance (for data integrity)
- Build an AMI – this will also create EBS snapshots
- Launch instances from other AMIs

EC2 Image Builder

- Used to automate the creation of Virtual Machines or container images
- => Automate the creation, maintain, validate and test EC2 AMIs
- Can be run on a schedule (weekly, whenever packages are updated, etc…)
- Free service (only pay for the underlying resources)

Elastic Load Balancing and Auto Scaling Groups

Scalability & High Availability

- Scalability means that an application / system can handle greater loads by adapting.
- There are two kinds of scalability:
  - Vertical Scalability
  - Horizontal Scalability (= elasticity)
- Scalability is linked but different to High Availability
- Let's deep dive into the distinction, using a call center as an example

Vertical Scalability

- Vertical Scalability means increasing the size of the instance
- For example, your application runs on a t2.micro
- Scaling that application vertically means running it on a t2.large
- Vertical scalability is very common for non distributed systems, such as a database.
- There's usually a limit to how much you can vertically scale (hardware limit)

Horizontal Scalability

- Horizontal Scalability means increasing the number of instances / systems for your application
- Horizontal scaling implies distributed systems.
- This is very common for web applications / modern applications
- It's easy to horizontally scale thanks the cloud offerings such as Amazon EC2

High Availability

- High Availability usually goes hand in hand with horizontal scaling
- High availability means running your application / system in at least 2 Availability Zones
- The goal of high availability is to survive a data center loss (disaster)

High Availability & Scalability For EC2

- Vertical Scaling: Increase instance size (= scale up / down)
  - From: t2.nano - 0.5G of RAM, 1 vCPU
  - To: u-12tb1.metal – 12.3 TB of RAM, 448 vCPUs
- Horizontal Scaling: Increase number of instances (= scale out / in)
  - Auto Scaling Group
  - Load Balancer
- High Availability: Run instances for the same application across multi AZ
  - Auto Scaling Group multi AZ
  - Load Balancer multi AZ

Scalability vs Elasticity (vs Agility)

Scalability	Elasticity	Agility
ability to accommodate a larger load by making the hardware stronger (scale up), or by adding nodes (scale out)	once a system is scalable, elasticity means that there will be some “auto-scaling” so that the system can scale based on the load. This is “cloud-friendly”: pay-per-use, match demand, optimize costs	(not related to scalability - distractor) new IT resources are only a click away, which means that you reduce the time to make those resources available to your developers from weeks to just minutes.

What is load balancing?

- Load balancers are servers that forward internet traffic to multiple servers (EC2 Instances) downstream.

Why use a load balancer?

- Spread load across multiple downstream instances
- Expose a single point of access (DNS) to your application
- Seamlessly handle failures of downstream instances
- Do regular health checks to your instances
- Provide SSL termination (HTTPS) for your websites
- High availability across zones

Why use an Elastic Load Balancer?

- An ELB (Elastic Load Balancer) is a managed load balancer
  - AWS guarantees that it will be working
  - AWS takes care of upgrades, maintenance, high availability
  - AWS provides only a few configuration knobs
- It costs less to setup your own load balancer but it will be a lot more effort on your end (maintenance, integrations)
- 3 kinds of load balancers offered by AWS:
  - Application Load Balancer (HTTP / HTTPS only) – Layer 7
  - Network Load Balancer (ultra-high performance, allows for TCP) – Layer 4
  - Classic Load Balancer (slowly retiring) – Layer 4 & 7

What's an Auto Scaling Group?

- In real-life, the load on your websites and application can change
- In the cloud, you can create and get rid of servers very quickly
- The goal of an Auto Scaling Group (ASG) is to:
  - Scale out (add EC2 instances) to match an increased load
  - Scale in (remove EC2 instances) to match a decreased load
  - Ensure we have a minimum and a maximum number of machines running
  - Automatically register new instances to a load balancer
  - Replace unhealthy instances
- Cost Savings: only run at an optimal capacity (principle of the cloud)

Auto Scaling Groups Scaling Strategies

- Manual Scaling: Update the size of an ASG manually
- Dynamic Scaling: Respond to changing demand
  - Simple / Step Scaling
    - When a CloudWatch alarm is triggered (example CPU > 70%), then add 2 units
    - When a CloudWatch alarm is triggered (example CPU < 30%), then remove 1
  - Target Tracking Scaling
    - Example: I want the average ASG CPU to stay at around 40%
  - Scheduled Scaling
    - Anticipate a scaling based on known usage patterns
    - Example: increase the min. capacity to 10 at 5 pm on Fridays
- Predictive Scaling
  - Uses Machine Learning to predict future traffic ahead of time
  - Automatically provisions the right number of EC2 instances in advance
- Useful when your load has predictable time - based patterns

ELB & ASG Summary

- High Availability vs Scalability (vertical and horizontal) vs Elasticity vs Agility in the Cloud
- Elastic Load Balancers (ELB)
  - Distribute traffic across backend EC2 instances, can be Multi-AZ
  - Supports health checks
  - 3 types: Application LB (HTTP – L7), Network LB (TCP – L4), Classic LB (old)
- Auto Scaling Groups (ASG)
  - Implement Elasticity for your application, across multiple AZ
  - Scale EC2 instances based on the demand on your system, replace unhealthy
  - Integrated with the ELB

Elastic Load Balancing & Auto Scaling Groups

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Amazon S3

- Amazon S3
    - S3 Use cases
    - Amazon S3 Overview - Buckets
    - Amazon S3 Overview - Objects
    - S3 Security
    - S3 Bucket Policies
    - Bucket settings for Block Public Access
    - S3 Websites
    - S3 - Versioning

S3 Use cases

- Backup and storage
- Disaster Recovery
- Archive
- Hybrid Cloud storage
- Application hosting
- Media hosting
- Data lakes & big data analytics
- Software delivery
- Static website

Amazon S3 Overview - Buckets

- Amazon S3 allows people to store objects (files) in “buckets” (directories)
- Buckets must have a globally unique name (across all regions all accounts)
- Buckets are defined at the region level
- S3 looks like a global service but buckets are created in a region

- Naming convention
  - No uppercase
  - No underscore
  - 3-63 characters long
  - Not an IP
  - Must start with lowercase letter or number

Amazon S3 Overview - Objects

- Objects (files) have a Key
- The key is the FULL path:
  - s3://my-bucket/my_file.txt
  - s3://my-bucket/my_folder1/another_folder/my_file.txt
- The key is composed of **prefix** + **object name**
  - s3://my-bucket/my_folder1/another_folder/my_file.txt
- There's no concept of "directories" within buckets (although the UI will trick you to think otherwise)
- Just keys with very long names that contain slashes ("/")
- Object values are the content of the body:
  - Max Object Size is 5TB (5000GB)
  - If uploading more than 5GB, must use "multi-part upload"
- Metadata (list of text key / value pairs – system or user metadata)
  - Tags (Unicode key / value pair – up to 10) – useful for security / lifecycle
  - Version ID (if versioning is enabled)

S3 Security

- **User based**
  - IAM policies - which API calls should be allowed for a specific user from IAM console
- **Resource Based**
  - Bucket Policies - bucket wide rules from the S3 console - allows cross account
  - Object Access Control List (ACL) – finer grain
  - Bucket Access Control List (ACL) – less common
- **Note:** an IAM principal can access an S3 object if
  - the user IAM permissions allow it OR the resource policy ALLOWS it
  - AND there's no explicit DENY
- **Encryption:** encrypt objects in Amazon S3 using encryption keys

S3 Bucket Policies

- JSON based policies
  - Resources: buckets and objects
  - Actions: Set of API to Allow or Deny
  - Effect: Allow / Deny Principal: The account or user to apply the policy to
- Use S3 bucket for policy to:
  - Grant public access to the bucket
  - Force objects to be encrypted at upload
  - Grant access to another account (Cross Account)

```
{
  "Version": "2012-10-17",
  "Statement": [
    {
      "sid": "PublicRead",
      "Effect": "Allow",
      "Principal": "*",
      "Action": [
        "s3:GetObject"
      ],
      "Resource": [
        "arn:aws:s3::examplebucket/*"
      ]
    }
  ]
}
```

Bucket settings for Block Public Access

- Block all public access: On
    - Block public access to buckets and objects granted through new access control lists (ACLS): On
    - Block public access to buckets and objects granted through any access control lists (ACLS): On
    - Block public access to buckets and objects granted through new public bucket or access point policies: On
    - Block public and cross-account access to buckets and objects through any public bucket or access point policies: On
- These settings were created to prevent company data leaks
- If you know your bucket should never be public, leave these on
- Can be set at the account level

S3 Websites

- S3 can host static websites and have them accessible on the www
- The website URL will be:
- bucket-name.s3-website-AWS-region.amazonaws.com OR
- bucket-name.s3-website.AWS-region.amazonaws.com
- **If you get a 403 (Forbidden) error, make sure the bucket policy allows public reads!**

S3 - Versioning

- You can version your files in Amazon S3
- It is enabled at the bucket level
- Same key overwrite will increment the “version”: 1, 2, 3....
- It is best practice to version your buckets
    - Protect against unintended deletes (ability to restore a version)

    - Easy roll back to previous version
- Notes:
    - Any file that is not versioned prior to enabling versioning will have version “null”
    - Suspending versioning does not delete the previous versions

S3 Access Logs

- For audit purpose, you may want to log all access to S3 buckets
- Any request made to S3, from any account, authorized or denied, will be logged into another S3 bucket
- That data can be analyzed using data analysis tools...
- Very helpful to come down to the root cause of an issue, or audit usage, view suspicious patterns, etc...

S3 Replication (CRR & SRR)

- Must enable versioning in source and destination
- Cross Region Replication (CRR)
- Same Region Replication (SRR)
- Buckets can be in different accounts
- Copying is asynchronous
- Must give proper IAM permissions to S3
- CRR - Use cases: compliance, lower latency access, replication across accounts
- SRR – Use cases: log aggregation, live replication between production and test accounts

S3 Storage Classes

- Amazon S3 Standard - General Purpose
- Amazon S3 Standard - Infrequent Access (IA)
- Amazon S3 One Zone - Infrequent Access
- Amazon S3 Glacier Instant Retrieval
- Amazon S3 Glacier Flexible Retrieval
- Amazon S3 Glacier Deep Archive
- Amazon S3 Intelligent Tiering
- Can move between classes manually or using S3 Lifecycle configurations

S3 Durability and Availability

- Durability:
    - High durability (99.999999999%, 11 9’s) of objects across multiple AZ
    - If you store 10,000,000 objects with Amazon S3, you can on average expect to incur a loss of a single object once every 10,000 years
    - Same for all storage classes
- Availability:
    - Measures how readily available a service is
    - Varies depending on storage class

    - Example: S3 standard has 99.99% availability = not available 53 minutes a year

S3 Standard General Purpose

- 99.99% Availability
- Used for frequently accessed data
- Low latency and high throughput
- Sustain 2 concurrent facility failures
- Use Cases: Big Data analytics, mobile & gaming applications, content distribution...

S3 Storage Classes - Infrequent Access

- For data that is less frequently accessed, but requires rapid access when needed
- Lower cost than S3 Standard

S3 Standard Infrequent Access (S3 Standard-IA)

- 99.9% Availability
- Use cases: Disaster Recovery, backups

S3 One Zone Infrequent Access (S3 One Zone-IA)

- High durability (99.999999999%) in a single AZ; data lost when AZ is destroyed
- 99.5% Availability
- Use Cases: Storing secondary backup copies of on-premise data, or data you can recreate

Amazon S3 Glacier Storage Classes

- Low-cost object storage meant for archiving / backup
- Pricing: price for storage + object retrieval cost

Amazon S3 Glacier Instant Retrieval

- Millisecond retrieval, great for data accessed once a quarter
- Minimum storage duration of 90 days

Amazon S3 Glacier Flexible Retrieval (formerly Amazon S3 Glacier)

- Expedited (1 to 5 minutes), Standard (3 to 5 hours), Bulk (5 to 12 hours) – free
- Minimum storage duration of 90 days

Amazon S3 Glacier Deep Archive - for long term storage

- Standard (12 hours), Bulk (48 hours)
- Minimum storage duration of 180 days

S3 Intelligent-Tiering

- Small monthly monitoring and auto-tiering fee
- Moves objects automatically between Access Tiers based on usage

- There are no retrieval charges in S3 Intelligent-Tiering
- Frequent Access tier (automatic): default tier
- Infrequent Access tier (automatic): objects not accessed for 30 days
- Archive Instant Access tier (automatic): objects not accessed for 90 days
- Archive Access tier (optional): configurable from 90 days to 700+ days
- Deep Archive Access tier (optional): config. from 180 days to 700+ days

S3 Object Lock & Glacier Vault Lock

- S3 Object Lock
  - Adopt a WORM (Write Once Read Many) model
  - Block an object version deletion for a specified amount of time
- Glacier Vault Lock
  - Adopt a WORM (Write Once Read Many) model
  - Lock the policy for future edits (can no longer be changed)
  - Helpful for compliance and data retention

Shared Responsibility Model for S3

AWS	YOU
Infrastructure (global security, durability, availability, sustain concurrent loss of data in two facilities)	S3 Versioning, S3 Bucket Policies, S3 Replication Setup
Configuration and vulnerability analysis	Logging and Monitoring, S3 Storage Classes
Compliance validation	Data encryption at rest and in transit

AWS Snow Family

- Highly-secure, portable devices to collect and process data at the edge, and migrate data into and out of AWS
- Data migration:
  - Snowcone
  - Snowball Edge
  - Snowmobile
- Edge computing:
  - Snowcone
  - Snowball Edge

Data Migrations with AWS Snow Family

- **AWS Snow Family: offline devices to perform data migrations** If it takes more than a week to transfer over the network, use Snowball devices!

- Challenges:

  - Limited connectivity

    - Limited bandwidth
    - High network cost
    - Shared bandwidth (can't maximize the line)
    - Connection stability

Time to Transfer

Data	100 Mbps	1Gbps	10Gbps
10 TB	12 days	30 hours	3 hours
100 TB	124 days	12 days	30 hours
1 PB	3 years	124 days	12 days

Snowball Edge (for data transfers)

- Physical data transport solution: move TBs or PBs of data in or out of AWS
- Alternative to moving data over the network (and paying network fees)
- Pay per data transfer job
- Provide block storage and Amazon S3-compatible object storage
- Snowball Edge Storage Optimized
    - 80 TB of HDD capacity for block volume and S3 compatible object storage
- Snowball Edge Compute Optimized
    - 42 TB of HDD capacity for block volume and S3 compatible object storage
- Use cases: large data cloud migrations, DC decommission, disaster recovery

AWS Snowcone

- Small, portable computing, anywhere, rugged & secure, withstands harsh environments
- Light (4.5 pounds, 2.1 kg)
- Device used for edge computing, storage, and data transfer
- **8 TBs of usable storage**
- Use Snowcone where Snowball does not fit (space-constrained environment)
- Must provide your own battery / cables
- Can be sent back to AWS offline, or connect it to internet and use **AWS DataSync** to send data

AWS Snowmobile

- Transfer exabytes of data (1 EB = 1,000 PB = 1,000,000 TBs)
- Each Snowmobile has 100 PB of capacity (use multiple in parallel)
- High security: temperature controlled, GPS, 24/7 video surveillance
- **Better than Snowball if you transfer more than 10 PB**

Properties	Snowcone	Snowball Edge Storage Optimized	Snowmobile
Storage Capacity	8 TB usable	80 TB usable	< 100 PB

Properties	Snowcone	Snowball Edge Storage Optimized	Snowmobile
Migration Size	Up to 24 TB, online and offline	Up to petabytes, offline	Up to exabytes, offline

Snow Family - Usage Process

1. Request Snowball devices from the AWS console for delivery
2. Install the snowball client / AWS OpsHub on your servers
3. Connect the snowball to your servers and copy files using the client
4. Ship back the device when you're done (goes to the right AWS facility)
5. Data will be loaded into an S3 bucket
6. Snowball is completely wiped

What is Edge Computing?

- Process data while it's being created on an edge location
  - A truck on the road, a ship on the sea, a mining station underground...
- These locations may have
  - Limited / no internet access
  - Limited / no easy access to computing power
- We setup a **Snowball Edge / Snowcone** device to do edge computing
- Use cases of Edge Computing:
  - Preprocess data
  - Machine learning at the edge
  - Transcoding media streams
- Eventually (if need be) we can ship back the device to AWS (for transferring data for example)

Snow Family - Edge Computing

- **Snowcone (smaller)**
  - 2 CPUs, 4 GB of memory, wired or wireless access
  - USB-C power using a cord or the optional battery
- **Snowball Edge – Compute Optimized**
  - 52 vCPUs, 208 GiB of RAM
  - Optional GPU (useful for video processing or machine learning)
  - 42 TB usable storage
- **Snowball Edge – Storage Optimized**
  - Up to 40 vCPUs, 80 GiB of RAM
  - Object storage clustering available
- All: Can run EC2 Instances & AWS Lambda functions (using AWS IoT Greengrass)
- Long-term deployment options: 1 and 3 years discounted pricing

AWS OpsHub

- Historically, to use Snow Family devices, you needed a CLI (Command Line Interface tool)

- Today, you can use **AWS OpsHub** (a software you install on your computer / laptop) to manage your Snow Family Device
    - Unlocking and configuring single or clustered devices
    - Transferring files
    - Launching and managing instances running on Snow Family Devices
    - Monitor device metrics (storage capacity, active instances on your device)
    - Launch compatible AWS services on your devices (ex: Amazon EC2 instances, AWS DataSync, Network File System (NFS))

Hybrid Cloud for Storage

- AWS is pushing for "hybrid cloud"
    - Part of your infrastructure is on-premises
    - Part of your infrastructure is on the cloud
- This can be due to
    - Long cloud migrations
    - Security requirements
    - Compliance requirements
    - IT strategy
- S3 is a proprietary storage technology (unlike EFS / NFS), so how do you expose the S3 data on-premise?
- AWS Storage Gateway!

AWS Storage Gateway

- Bridge between on-premise data and cloud data in S3
- Hybrid storage service to allow on- premises to seamlessly use the AWS Cloud
- Use cases: disaster recovery, backup & restore, tiered storage
- Types of Storage Gateway:
    - File Gateway
    - Volume Gateway
    - Tape Gateway
- No need to know the types at the exam

Amazon S3 - Summary

- Buckets vs Objects: global unique name, tied to a region
- S3 security: IAM policy, S3 Bucket Policy (public access), S3 Encryption
- S3 Websites: host a static website on Amazon S3
- S3 Versioning: multiple versions for files, prevent accidental deletes
- S3 Access Logs: log requests made within your S3 bucket
- S3 Replication: same-region or cross-region, must enable versioning
- S3 Storage Classes: Standard, IA, 1Z-IA, Intelligent, Glacier, Glacier Deep Archive
- S3 Lifecycle Rules: transition objects between classes
- S3 Glacier Vault Lock / S3 Object Lock: WORM (Write Once Read Many)
- Snow Family: import data onto S3 through a physical device, edge computing
- OpsHub: desktop application to manage Snow Family devices
- Storage Gateway: hybrid solution to extend on-premises storage to S3

Databases and Analytics

Databases Intro

- Storing data on disk (EFS, EBS, EC2 Instance Store, S3) can have its limits
- Sometimes, you want to store data in a database...
- You can structure the data
- You build indexes to efficiently query / search through the data
- You define relationships between your datasets
- Databases are optimized for a purpose and come with different features, shapes and constraint

Relational Databases

- Looks just like Excel spreadsheets, with links between them!
- Can use the SQL language to perform queries / lookups

NoSQL Databases

- NoSQL = non-SQL = non relational databases

- NoSQL databases are purpose built for specific data models and have flexible schemas for building modern applications.
- Benefits:
  - Flexibility: easy to evolve data model
  - Scalability: designed to scale-out by using distributed clusters
  - High-performance: optimized for a specific data model
  - Highly functional: types optimized for the data model
- Examples: Key-value, document, graph, in-memory, search databases

NoSQL data example: JSON

- JSON = JavaScript Object Notation
- JSON is a common form of data that fits into a NoSQL model
- Data can be nested
- Fields can change over time
- Support for new types: arrays, etc...

```
{
  "name": "John",
  "age": 30,
  "cars": [
    "Ford",
    "BMW",
    "Fiat"
  ],
  "address": {
    "type": "house",
    "number": 23,
    "street": "Dream Road"
  }
}
```

Databases & Shared Responsibility on AWS

- AWS offers use to manage different databases
- Benefits include:
  - Quick Provisioning, High Availability, Vertical and Horizontal Scaling
  - Automated Backup & Restore, Operations, Upgrades
  - Operating System Patching is handled by AWS
  - Monitoring, alerting
- Note: many databases technologies could be run on EC2, but you must handle yourself the resiliency, backup, patching, high availability, fault tolerance, scaling

AWS RDS Overview

- RDS stands for Relational Database Service
- It's a managed DB service for DB use SQL as a query language.
- It allows you to create databases in the cloud that are managed by AWS

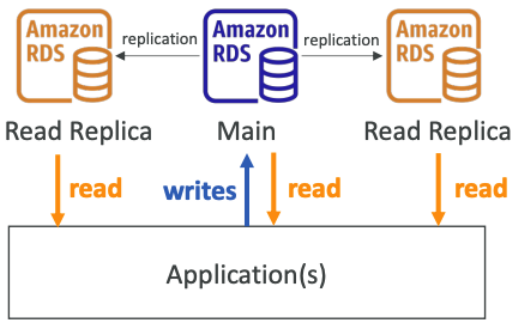
- Postgres
- MySQL
- MariaDB
- Oracle
- Microsoft SQL Server
- **Aurora (AWS Proprietary database)**

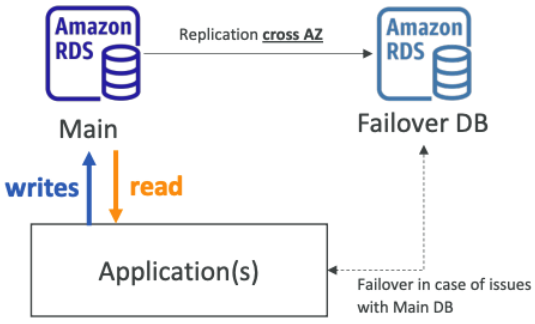
Advantage over using RDS versus deploying DB on EC2

- RDS is a managed service:
  - Automated provisioning, OS patching
  - Continuous backups and restore to specific timestamp (Point in Time Restore)!
  - Monitoring dashboards
  - Read replicas for improved read performance
  - Multi AZ setup for DR (Disaster Recovery)
  - Maintenance windows for upgrades
  - Scaling capability (vertical and horizontal)
  - Storage backed by EBS (gp2 or io1)
- BUT you can't SSH into your instances

RDS Deployments: Read Replicas, Multi-AZ

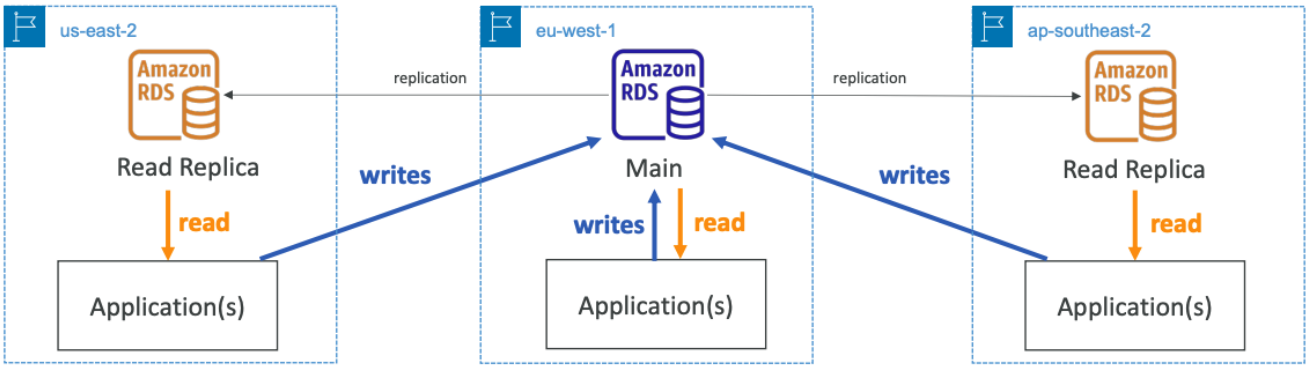
Read Replicas	**Multi-AZ**
Scale the read workload of your DB	Failover in case of AZ outage (high availability)
Can create up to 5 Read Replicas	Data is only read/written to the main database
Data is only written to the main DB	Can only have 1 other AZ as failover





RDS Deployments: Multi-Region

- Multi-Region (Read Replicas)
  - Disaster recovery in case of region issue
  - Local performance for global reads
  - Replication cost



Amazon Aurora

- Aurora is a proprietary technology from AWS (not open sourced)
- PostgreSQL and MySQL are both supported as Aurora DB
- Aurora is "AWS cloud optimized" and claims 5x performance improvement over MySQL on RDS, over 3x the performance of Postgres on RDS
- Aurora storage automatically grows in increments of 10GB, up to 64 TB.
- Aurora costs more than RDS (20% more) – but is more efficient
- Not in the free tier

Amazon ElastiCache Overview

- The same way RDS is to get managed Relational Databases…
- ElastiCache is to get managed Redis or Memcached
- Caches are in-memory databases with high performance, low latency
- Helps reduce load off databases for read intensive workloads
- AWS takes care of OS maintenance / patching, optimizations, setup, configuration, monitoring, failure recovery and backup

DynamoDB

- Fully Managed Highly available with replication across 3 AZ
- NoSQL database - not a relational database
- Scales to massive workloads, distributed "serverless" database
- Millions of requests per seconds, trillions of row, 100s of TB of storage
- Fast and consistent in performance
- Single-digit millisecond latency – low latency retrieval
- Integrated with IAM for security, authorization and administration
- Low cost and auto scaling capabilities
- Standard & Infrequent Access (IA) Table Class

DynamoDB Accelerator - DAX

- Fully Managed in-memory cache for DynamoDB
- 10x performance improvement – single- digit millisecond latency to microseconds latency – when accessing your DynamoDB tables
- Secure, highly scalable & highly available

- Difference with ElastiCache at the CCP level: DAX is only used for and is integrated with DynamoDB, while ElastiCache can be used for other databases

DynamoDB - Global Tables

- Make a DynamoDB table accessible with low latency in multiple-regions
- Active-Active replication (read/write to any AWS Region)

Redshift Overview

- Redshift is based on PostgreSQL, but it's not used for OLTP (Online Transactional Processing)
- It's OLAP – online analytical processing (analytics and data warehousing)
- Load data once every hour, not every second
- 10x better performance than other data warehouses, scale to PBs of data
- Columnar storage of data (instead of row based)
- Massively Parallel Query Execution (MPP), highly available
- Pay as you go based on the instances provisioned
- Has a SQL interface for performing the queries
- BI tools such as AWS Quicksight or Tableau integrate with it

Amazon EMR

- EMR stands for "Elastic MapReduce"
- EMR helps creating Hadoop clusters (Big Data) to analyze and process vast amount of data
- The clusters can be made of hundreds of EC2 instances
- Also supports Apache Spark, HBase, Presto, Flink
- EMR takes care of all the provisioning and configuration
- Auto-scaling and integrated with Spot instances
- Use cases: data processing, machine learning, web indexing, big data

Amazon Athena

- Serverless query service to analyze data stored in Amazon S3
- Uses standard SQL language to query the files
- Supports CSV, JSON, ORC, Avro, and Parquet (built on Presto)
- Pricing: $5.00 per TB of data scanned
- Use compressed or columnar data for cost-savings (less scan)
- Use cases: Business intelligence / analytics / reporting, analyze & query VPC Flow Logs, ELB Logs, CloudTrail trails, etc...
- **analyze data in S3 using serverless SQL, use Athena**

Amazon QuickSight

- Serverless machine learning-powered business intelligence service to create interactive dashboards
- Fast, automatically scalable, embeddable, with per-session pricing
- Use cases:
    - Business analytics
    - Building visualizations

    - Perform ad-hoc analysis
    - Get business insights using data
- Integrated with RDS, Aurora, Athena, Redshift, S3…

DocumentDB

- Aurora is an "AWS-implementation" of PostgreSQL / MySQL …
- DocumentDB is the same for MongoDB (which is a NoSQL database)
- MongoDB is used to store, query, and index JSON data
- Similar "deployment concepts" as Aurora
- Fully Managed, highly available with replication across 3 AZ
- Aurora storage automatically grows in increments of 10GB, up to 64 TB.
- Automatically scales to workloads with millions of requests per seconds

Amazon Neptune

- Fully managed graph database
- A popular graph dataset would be a social network
    - Users have friends
    - Posts have comments
    - Comments have likes from users
    - Users share and like posts…
- Highly available across 3 AZ, with up to 15 read replicas
- Build and run applications working with highly connected datasets – optimized for these complex and hard queries
- Can store up to billions of relations and query the graph with milliseconds latency
- Highly available with replications across multiple AZs
- Great for knowledge graphs (Wikipedia), fraud detection, recommendation engines, social networking

Amazon QLDB

- QLDB stands for "Quantum Ledger Database"
- A ledger is a book **recording financial transactions**
- Fully Managed, Serverless, High available, Replication across 3 AZ
- Used to **review history of all the changes made to your application data** over time
- **Immutable** system: no entry can be removed or modified, cryptographically verifiable
- 2-3x better performance than common ledger blockchain frameworks, manipulate data using SQL
- Difference with Amazon Managed Blockchain: no decentralization component, in accordance with financial regulation rules

Amazon Managed Blockchain

- Blockchain makes it possible to build applications where multiple parties can execute transactions without the need for a trusted, central authority.
- Amazon Managed Blockchain is a managed service to:
    - Join public blockchain networks
    - Or create your own scalable private network
- Compatible with the frameworks Hyperledger Fabric & Ethereum

AWS Glue

- Managed extract, transform, and load (ETL) service
- Useful to prepare and transform data for analytics
- Fully serverless service
- Glue Data Catalog: catalog of datasets
    - can be used by Athena, Redshift, EMR

DMS - Database Migration Service

- Quickly and securely migrate databases to AWS, resilient, self healing
- The source database remains available during the migration
- Supports:
    - Homogeneous migrations: ex Oracle to Oracle
    - Heterogeneous migrations: ex Microsoft SQL Server to Aurora

Databases & Analytics Summary

- Relational Databases - OLTP: RDS & Aurora (SQL)
- Differences between Multi-AZ, Read Replicas, Multi-Region
- In-memory Database: ElastiCache
- Key/Value Database: DynamoDB (serverless) & DAX (cache for DynamoDB)
- Warehouse - OLAP: Redshift (SQL)
- Hadoop Cluster: EMR
- Athena: query data on Amazon S3 (serverless & SQL)
- QuickSight: dashboards on your data (serverless)
- DocumentDB: “Aurora for MongoDB” (JSON – NoSQL database)
- Amazon QLDB: Financial Transactions Ledger (immutable journal, cryptographically verifiable)
- Amazon Managed Blockchain: managed Hyperledger Fabric & Ethereum blockchains
- Glue: Managed ETL (Extract Transform Load) and Data Catalog service
- Database Migration: DMS
- Neptune: graph database

Other Compute

What is Docker?

- Docker is a software development platform to deploy apps
- Apps are packaged in containers that can be run on any OS
- Apps run the same, regardless of where they’re run
    - Any machine
    - No compatibility issues
    - Predictable behavior
    - Less work
    - Easier to maintain and deploy
    - Works with any language, any OS, any technology
- Scale containers up and down very quickly (seconds)

Where Docker images are stored?

- Docker images are stored in Docker Repositories
- Public: Docker Hub https://hub.docker.com/
    - Find base images for many technologies or OS:
    - Ubuntu
    - MySQL
    - NodeJS, Java…
- Private: Amazon ECR (Elastic Container Registry)

Docker versus Virtual Machines

- Docker is “sort of” a virtualization technology, but not exactly
- Resources are shared with the host => many containers on one server

ECS

- ECS = Elastic Container Service
- Launch Docker containers on AWS
- You must provision & maintain the infrastructure (the EC2 instances)
- AWS takes care of starting / stopping containers
- Has integrations with the Application Load Balancer

Fargate

- Launch Docker containers on AWS
- You do not provision the infrastructure (no EC2 instances to manage) – simpler!
- Serverless offering

- AWS just runs containers for you based on the CPU / RAM you need

ECR

- Elastic Container Registry
- Private Docker Registry on AWS
- This is where you store your Docker images so they can be run by ECS or Fargate

What's serverless?

- Serverless is a new paradigm in which the developers don't have to manage servers anymore…
- They just deploy code
- They just deploy… functions !
- Initially… Serverless == FaaS (Function as a Service)
- Serverless was pioneered by AWS Lambda but now also includes anything that's managed: "databases, messaging, storage, etc."
- Serverless does not mean there are no servers…
- it means you just don't manage / provision / see them

Why AWS Lambda ?

EC2	**Lambda**
Virtual Servers in the Cloud	Virtual functions – no servers to manage!
Limited by RAM and CPU	Limited by time - short executions
Continuously running	Run on-demand
Scaling means intervention to add / remove servers	Scaling is automated!

Benefits of AWS Lambda

- Easy Pricing:
  - Pay per request and compute time
  - Free tier of 1,000,000 AWS Lambda requests and 400,000 GBs of compute time
- Integrated with the whole AWS suite of services
- Event-Driven: functions get invoked by AWS when needed
- Integrated with many programming languages
- Easy monitoring through AWS CloudWatch
- Easy to get more resources per functions (up to 10GB of RAM!)
- Increasing RAM will also improve CPU and network!

AWS Lambda language support

- Node.js (JavaScript)
- Python
- Java (Java 8 compatible)
- C# (.NET Core)
- Golang

- C# / Powershell
- Ruby
- Custom Runtime API (community supported, example Rust)
- Lambda Container Image
    - The container image must implement the Lambda Runtime API
    - ECS / Fargate is preferred for running arbitrary Docker images

AWS Lambda Pricing: example

- You can find overall pricing information here: https://aws.amazon.com/lambda/pricing/
- Pay per calls:
    - First 1,000,000 requests are free
    - $0.20 per 1 million requests thereafter ($0.0000002 per request)
- Pay per duration: (in increment of 1 ms)
    - 400,000 GB-seconds of compute time per month for FREE
    - == 400,000 seconds if function is 1GB RAM
    - == 3,200,000 seconds if function is 128 MB RAM
    - After that $1.00 for 600,000 GB-seconds
- It is usually **very cheap** to run AWS Lambda so it's **very popular**

Amazon API Gateway

- Example: building a serverless API
- Fully managed service for developers to easily create, publish, maintain, monitor, and secure APIs
- Serverless and scalable
- Supports RESTful APIs and WebSocket APIs
- Support for security, user authentication, API throttling, API keys, monitoring.

AWS Batch

- Fully managed batch processing at any scale
- Efficiently run 100,000s of computing batch jobs on AWS
- A "batch" job is a job with a start and an end (opposed to continuous)
- Batch will dynamically launch EC2 instances or Spot Instances
- AWS Batch provisions the right amount of compute / memory
- You submit or schedule batch jobs and AWS Batch does the rest!
- Batch jobs are defined as Docker images and run on ECS
- Helpful for cost optimizations and focusing less on the infrastructure

Batch vs Lambda

Batch	**Lambda**
No time limit	Time limit
Any runtime as long as it's packaged as a Docker image	Limited runtime
Rely on EBS / instance store for disk space	Limited temporary disk space
Relies on EC2 (can be managed by AWS)	Serverless

Amazon Lightsail

- Virtual servers, storage, databases, and networking
- Low & predictable pricing
- Simpler alternative to using EC2, RDS, ELB, EBS, Route 53...
- Great for people with little cloud experience!
- Can setup notifications and monitoring of your Lightsail resources
- Use cases:
  - Simple web applications (has templates for LAMP, Nginx, MEAN, Node.js...)
  - Websites (templates for WordPress, Magento, Plesk, Joomla)
  - Dev / Test environment
- Has high availability but no auto-scaling, limited AWS integrations

Lambda Summary

- Lambda is Serverless, Function as a Service, seamless scaling, reactive
- Lambda Billing:
  - By the time run x by the RAM provisioned
  - By the number of invocations
- Language Support: many programming languages except (arbitrary) Docker
- Invocation time: up to 15 minutes
- Use cases:
  - Create Thumbnails for images uploaded onto S3
  - Run a Serverless cron job
- API Gateway: expose Lambda functions as HTTP API

Other Compute Summary

- Docker: container technology to run applications
- ECS: run Docker containers on EC2 instances
- Fargate:
- Run Docker containers without provisioning the infrastructure
- Serverless offering (no EC2 instances)
- ECR: Private Docker Images Repository
- Batch: run batch jobs on AWS across managed EC2 instances
- Lightsail: predictable & low pricing for simple application & DB stacks

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Deploying and Managing Infrastructure at Scale

    - AWS Elastic Beanstalk Overview
        - Elastic Beanstalk - Health Monitoring
    - AWS CodeDeploy
    - AWS CodeCommit
    - AWS CodeBuild
    - AWS CodePipeline
    - AWS CodeArtifact
    - AWS CodeStar
    - AWS Cloud9
    - AWS Systems Manager (SSM)
        - How Systems Manager works
        - Systems Manager - SSM Session Manager
    - AWS OpsWorks
        - OpsWorks Architecture
    - Deployment - Summary
    - Developer Services - Summary

What is CloudFormation?

- CloudFormation is a declarative way of outlining your AWS Infrastructure, for any resources (most of them are supported).
- For example, within a CloudFormation template, you say:
    - I want a security group
    - I want two EC2 instances using this security group
    - I want an S3 bucket
    - I want a load balancer (ELB) in front of these machines
- Then CloudFormation creates those for you, in the right order, with the exact configuration that you specify

Benefits of AWS CloudFormation

- Infrastructure as code
    - No resources are manually created, which is excellent for control
    - Changes to the infrastructure are reviewed through code
- Cost
    - Each resources within the stack is tagged with an identifier so you can easily see how much a stack costs you
    - You can estimate the costs of your resources using the CloudFormation template
    - Savings strategy: In Dev, you could automation deletion of templates at 5 PM and recreated at 8 AM, safely
- Productivity
    - Ability to destroy and re-create an infrastructure on the cloud on the fly
    - Automated generation of Diagram for your templates!
    - Declarative programming (no need to figure out ordering and orchestration)
- Don't re-invent the wheel
    - Leverage existing templates on the web!
    - Leverage the documentation

- Supports (almost) all AWS resources:
  - Everything we'll see in this course is supported
  - You can use "custom resources" for resources that are not supported

CloudFormation Stack Designer

- Example: WordPress CloudFormation Stack
- We can see all the resources
- We can see the relations between the components

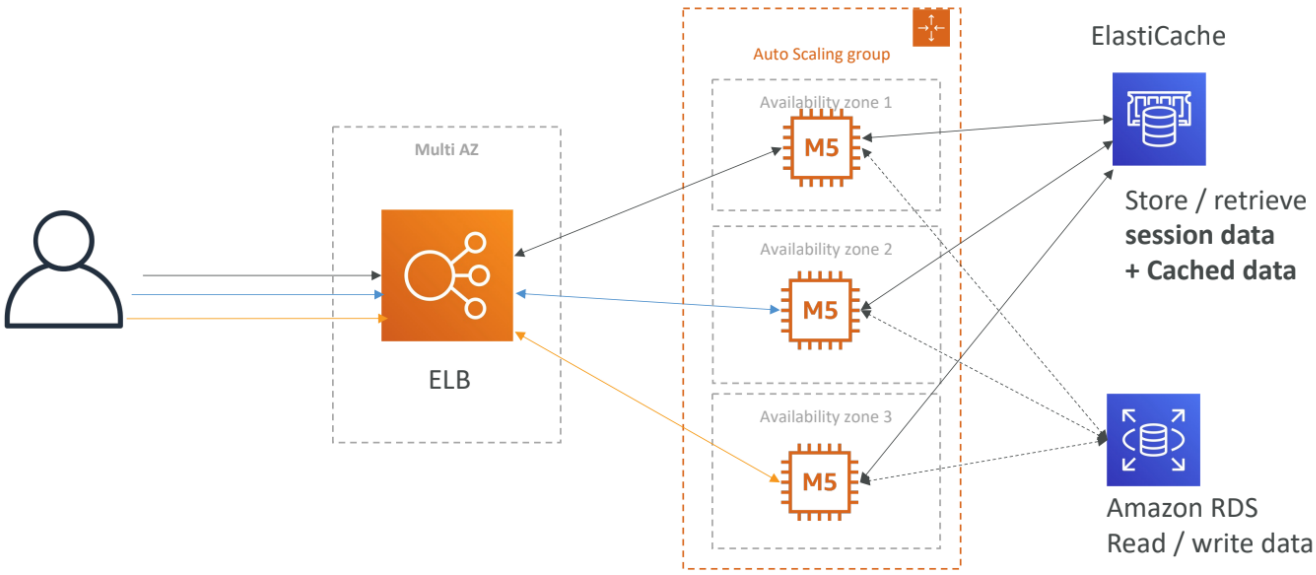
AWS Cloud Development Kit (CDK)

- Define your cloud infrastructure using a familiar language:
  - JavaScript/TypeScript, Python, Java, and .NET
- The code is "compiled" into a CloudFormation template (JSON/YAML)
- You can therefore deploy infrastructure and application runtime code together
  - Great for Lambda functions
  - Great for Docker containers in ECS / EKS

Developer problems on AWS

- Managing infrastructure
- Deploying Code
- Configuring all the databases, load balancers, etc
- Scaling concerns
- Most web apps have the same architecture (ALB + ASG)
- All the developers want is for their code to run!
- Possibly, consistently across different applications and environments

Typical architecture: Web App 3-tier



AWS Elastic Beanstalk Overview

- Elastic Beanstalk is a developer centric view of deploying an application on AWS
- It uses all the component's we've seen before: EC2, ASG, ELB, RDS, etc...
- But it's all in one view that's easy to make sense of!
- We still have full control over the configuration
- Beanstalk = Platform as a Service (PaaS)
- Beanstalk is free but you pay for the underlying instances
- Managed service
    - Instance configuration / OS is handled by Beanstalk
    - Deployment strategy is configurable but performed by Elastic Beanstalk
    - Capacity provisioning
    - Load balancing & auto-scaling
- Application health-monitoring & responsiveness
- Just the application code is the responsibility of the developer
- Three architecture models:
    - Single Instance deployment: good for dev
    - LB + ASG: great for production or pre-production web applications
    - ASG only: great for non-web apps in production (workers, etc..)
- Support for many platforms:
    - Go
    - Java SE
    - Java with Tomcat
    - .NET on Windows Server with IIS
    - Node.js
    - PHP
    - Python
    - Ruby
    - Packer Builder
    - Single Container Docker
    - Multi-Container Docker
    - Preconfigured Docker

Elastic Beanstalk - Health Monitoring

- Health agent pushes metrics to CloudWatch
- Checks for app health, publishes health events

AWS CodeDeploy

- We want to deploy our application automatically

- Works with EC2 Instances
- Works with On-Premises Servers
- Hybrid service
- Servers / Instances must be provisioned and configured ahead of time with the CodeDeploy Agent

AWS CodeCommit

- Before pushing the application code to servers, it needs to be stored somewhere
- Developers usually store code in a repository, using the Git technology
- A famous public offering is GitHub, AWS' competing product is CodeCommit
- CodeCommit:
  - Source-control service that hosts Git-based repositories
  - Makes it easy to collaborate with others on code
  - The code changes are automatically versioned
- Benefits:
  - Fully managed
  - Scalable & highly available
  - Private, Secured, Integrated with AWS

AWS CodeBuild

- Code building service in the cloud (name is obvious)
- Compiles source code, run tests, and produces packages that are ready to be deployed (by CodeDeploy for example)
- Benefits:
  - Fully managed, serverless
  - Continuously scalable & highly available
  - Secure
  - Pay-as-you-go pricing – only pay for the build time

AWS CodePipeline

- Orchestrate the different steps to have the code automatically pushed to production
- Code => Build => Test => Provision => Deploy
- Basis for CICD (Continuous Integration & Continuous Delivery)
- Benefits:
  - Fully managed, compatible with CodeCommit, CodeBuild, CodeDeploy, Elastic Beanstalk, CloudFormation, GitHub, 3rd-party services (GitHub…) & custom plugins…
  - Fast delivery & rapid updates
- CodePipeline: orchestration layer
  - CodeCommit => CodeBuild => CodeDeploy => Elastic Beanstalk

AWS CodeArtifact

- Software packages depend on each other to be built (also called code dependencies), and new ones are created
- Storing and retrieving these dependencies is called artifact management
- Traditionally you need to setup your own artifact management system
- CodeArtifact is a secure, scalable, and cost-effective artifact management for software development
- Works with common dependency management tools such as Maven, Gradle, npm, yarn, twine, pip, and NuGet
- Developers and CodeBuild can then retrieve dependencies straight from CodeArtifact

AWS CodeStar

- Unified UI to easily manage software development activities in one place
- "Quick way" to get started to correctly set-up CodeCommit, CodePipeline, CodeBuild, CodeDeploy, Elastic Beanstalk, EC2, etc…
- Can edit the code "in-the-cloud" using AWS Cloud9

AWS Cloud9

- AWS Cloud9 is a cloud IDE (Integrated Development Environment) for writing, running and debugging code
- "Classic" IDE (like IntelliJ, Visual Studio Code…) are downloaded on a computer before being used
- A cloud IDE can be used within a web browser, meaning you can work on your projects from your office, home, or anywhere with internet with no setup necessary
- AWS Cloud9 also allows for code collaboration in real-time (pair programming)

AWS Systems Manager (SSM)

- Helps you manage your EC2 and On-Premises systems at scale
- Another Hybrid AWS service
- Get operational insights about the state of your infrastructure
- Suite of 10+ products
- Most important features are:
    - Patching automation for enhanced compliance
    - Run commands across an entire fleet of servers
    - Store parameter configuration with the SSM Parameter Store
- Works for both Windows and Linux OS

How Systems Manager works

- We need to install the SSM agent onto the systems we control
- Installed by default on Amazon Linux AMI & some Ubuntu AMI
- If an instance can't be controlled with SSM, it's probably an issue with the SSM agent!
- Thanks to the SSM agent, we can run commands, patch & configure our servers

Systems Manager - SSM Session Manager

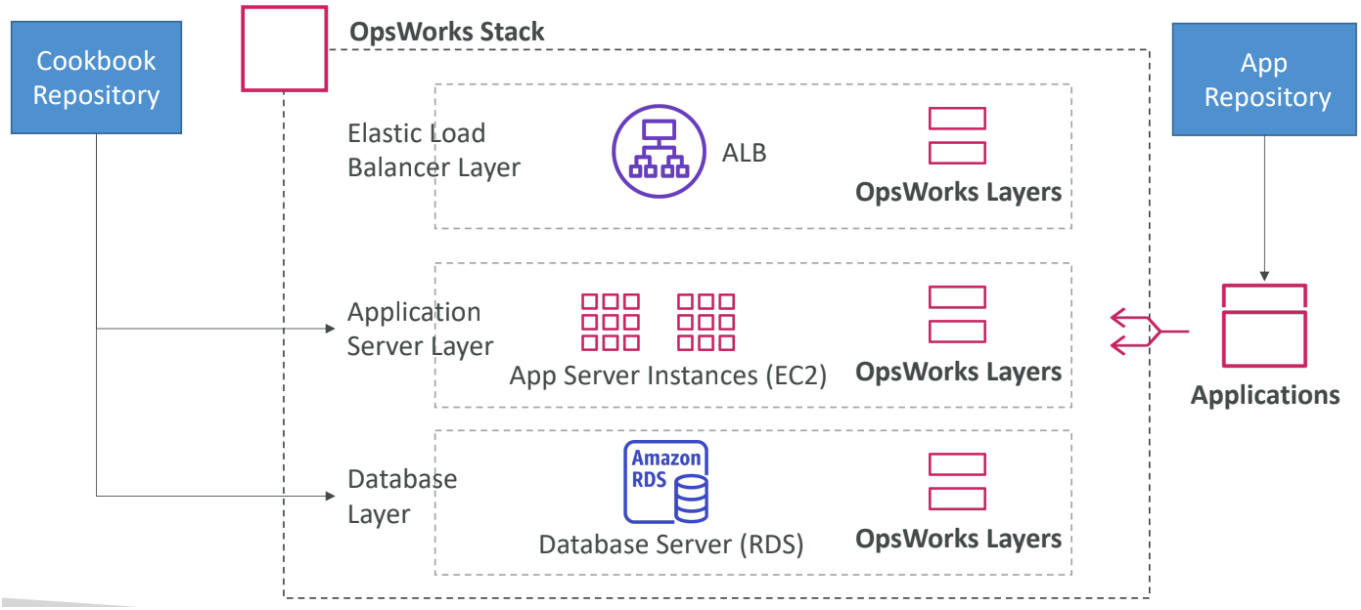
- Allows you to start a secure shell on your EC2 and on-premises servers
- No SSH access, bastion hosts, or SSH keys needed
- No port 22 needed (better security)

- Supports Linux, macOS, and Windows
- Send session log data to S3 or CloudWatch Logs

AWS OpsWorks

- Chef & Puppet help you perform server configuration automatically, or repetitive actions
- They work great with EC2 & On-Premises VM
- AWS OpsWorks = Managed Chef & Puppet
- It's an alternative to AWS SSM
- Only provision standard AWS resources:
  - EC2 Instances, Databases, Load Balancers, EBS volumes...
- **Chef or Puppet needed => AWS OpsWorks**

OpsWorks Architecture



Deployment - Summary

- CloudFormation: (AWS only)
  - Infrastructure as Code, works with almost all of AWS resources
  - Repeat across Regions & Accounts
- Beanstalk: (AWS only)
  - Platform as a Service (PaaS), limited to certain programming languages or Docker
  - Deploy code consistently with a known architecture: ex, ALB + EC2 + RDS
- CodeDeploy (hybrid): deploy & upgrade any application onto servers
- Systems Manager (hybrid): patch, configure and run commands at scale
- OpsWorks (hybrid): managed Chef and Puppet in AWS

Developer Services - Summary

- CodeCommit: Store code in private git repository (version controlled)
- CodeBuild: Build & test code in AWS
- CodeDeploy: Deploy code onto servers

- CodePipeline: Orchestration of pipeline (from code to build to deploy)
- CodeArtifact: Store software packages / dependencies on AWS
- CodeStar: Unified view for allowing developers to do CICD and code
- Cloud9: Cloud IDE (Integrated Development Environment) with collab
- AWS CDK: Define your cloud infrastructure using a programming language

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Global Infrastructure

Why make a global application?

- A global application is an application deployed in **multiple geographies**
- On AWS: this could be **Regions** and / or **Edge Locations**
- **Decreased Latency**
  - Latency is the time it takes for a network packet to reach a server
  - It takes time for a packet from Asia to reach the US
  - Deploy your applications closer to your users to decrease latency, better experience
- **Disaster Recovery (DR)**
  - If an AWS region goes down (earthquake, storms, power shutdown, politics)...
  - You can fail-over to another region and have your application still working
  - A DR plan is important to increase the availability of your application
- **Attack protection**: distributed global infrastructure is harder to attack

Global AWS Infrastructure

- Regions: For deploying applications and infrastructure
- Availability Zones: Made of multiple data centers
- Edge Locations (Points of Presence): for content delivery as close as possible to users
- More at: https://infrastructure.aws/

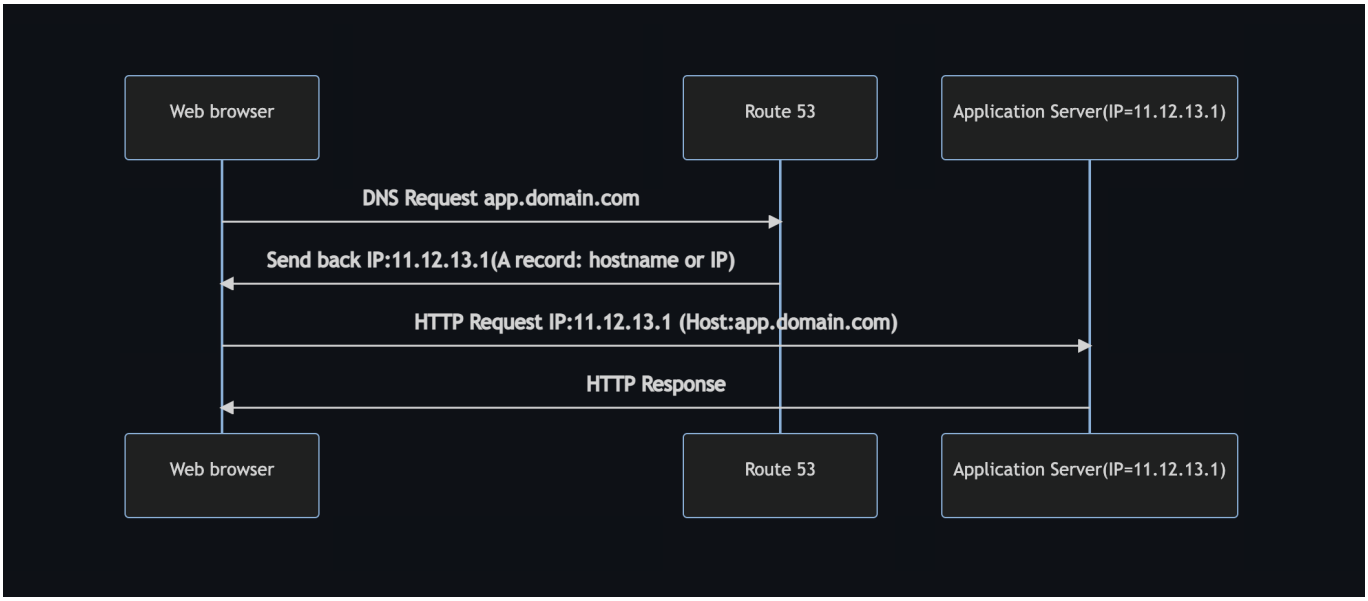
Global Applications in AWS

- **Global DNS: Route 53**
  - Great to route users to the closest deployment with least latency
  - Great for disaster recovery strategies
- **Global Content Delivery Network (CDN): CloudFront**
  - Replicate part of your application to AWS Edge Locations – decrease latency
  - Cache common requests – improved user experience and decreased latency
- **S3 Transfer Acceleration**
  - Accelerate global uploads & downloads into Amazon S3
- **AWS Global Accelerator:**
  - Improve global application availability and performance using the AWS global network

Amazon Route 53 Overview

- Route53 is a Managed DNS (Domain Name System)
- DNS is a collection of rules and records which helps clients understand how to reach a server through URLs.
- In AWS, the most common records are:
  - www.google.com => 12.34.56.78 == A record (IPv4)
  - www.google.com => 2001:0db8:85a3:0000:0000:8a2e:0370:7334 == AAAA IPv6
  - search.google.com => www.google.com == CNAME: hostname to hostname
  - example.com => AWS resource == Alias (ex: ELB, CloudFront, S3, RDS, etc...)

Route 53 - Diagram for A Record



Route 53 Routing Policies

Need to know them at a high-level for the Cloud Practitioner Exam

- simple routing policy
- weighted routing policy
- latency routing policy
- failover routing policy

simple routing policy

- Use for a single resource that performs a given function for your domain
- for example, a web server that serves content for the example.com website.
- You can use simple routing to create records in a private hosted zone

weighted routing policy

- Use to route traffic to multiple resources in proportions that you specify.
- You can use weighted routing to create records in a private hosted zone.

latency routing policy

- Use when you have resources in multiple AWS Regions and you want to route traffic to the region that provides the best latency.
- You can use latency routing to create records in a private hosted zone.

failover routing policy

- Use when you want to configure active-passive failover.
- You can use failover routing to create records in a private hosted zone.

AWS CloudFront

- Content Delivery Network (CDN)
- **Improves read performance, content is cached at the edge**
- Improves users experience
- 216 Point of Presence globally (edge locations)
- DDoS protection (because worldwide), integration with Shield, AWS Web Application Firewall
- Source: https://aws.amazon.com/cloudfront/features/?nc=sn&loc=2

CloudFront - Origins

- S3 bucket
  - For distributing files and caching them at the edge
  - Enhanced security with CloudFront Origin Access Identity (OAI)
  - CloudFront can be used as an ingress (to upload files to S3)
- Custom Origin (HTTP)
  - Application Load Balancer
  - EC2 instance
  - S3 website (must first enable the bucket as a static S3 website)

- Any HTTP backend you want

CloudFront vs S3 Cross Region Replication

CloudFront	S3 Cross Region Replication
Global Edge network	Must be setup for each region you want replication to happen
Files are cached for a TTL (Time to Live) (maybe a day)	Files are updated in near real-time, Read only
Great for static content that must be available everywhere	**Great for dynamic content that needs to be available at low-latency in few regions**

S3 Transfer Acceleration

- Increase transfer speed by transferring file to an AWS edge location which will forward the data to the S3 bucket in the target region
- if we try to upload file to Australia S3 bucket it will take time using CloudFront we can rescue time.
- File in USA -> Edge Location(USA) -> S3 Bucket(Australia)
- Test the tool at: https://s3-accelerate-speedtest.s3-accelerate.amazonaws.com/en/accelerate-speed-comparsion.html

AWS Global Accelerator

- Improve global application availability and performance using the AWS global network
- Leverage the AWS internal network to optimize the route to your application (60% improvement)
- 2 Anycast IP are created for your application and traffic is sent through Edge Locations
- The Edge locations send the traffic to your application
- Test the tool at: https://speedtest.globalaccelerator.aws/#/

AWS Global Accelerator vs CloudFront

- They both use the AWS global network and its edge locations around the world
- Both services integrate with AWS Shield for DDoS protection.
- CloudFront – Content Delivery Network
  - Improves performance for your cacheable content (such as images and videos)
  - Content is served at the edge
- Global Accelerator
  - No caching, proxying packets at the edge to applications running in one or more AWS Regions.
  - Improves performance for a wide range of applications over TCP or UDP
  - Good for HTTP use cases that require static IP addresses
  - Good for HTTP use cases that required deterministic, fast regional failover

AWS Outposts

- **Hybrid Cloud**: businesses that keep an on - premises infrastructure alongside a cloud infrastructure
- Therefore, two ways of dealing with IT systems: • One for the AWS cloud (using the AWS console, CLI, and AWS APIs)

- One for their on-premises infrastructure
- **AWS Outposts are "server racks"** that offers the same AWS infrastructure, services, APIs & tools to build your own applications on-premises just as in the cloud
- **AWS will setup and manage "Outposts Racks"** within your on-premises infrastructure and you can start leveraging AWS services on-premises
- You are responsible for the Outposts Rack physical security

AWS Outposts Benefits

- Low-latency access to on-premises systems
- Local data processing
- Data residency
- Easier migration from on-premises to the cloud
- Fully managed service
- Some services that work on Outposts:
    - EC2
    - EBS
    - S3
    - EKS
    - ECS
    - RDS
    - EMR

AWS WaveLength

- WaveLength Zones are infrastructure deployments embedded within the telecommunications providers' datacenters at the edge of the 5G networks
- Brings AWS services to the edge of the 5G networks
- Example: EC2, EBS, VPC…
- Ultra-low latency applications through 5G networks
- Traffic doesn't leave the Communication Service Provider's (CSP) network
- High-bandwidth and secure connection to the parent AWS Region
- No additional charges or service agreements
- Use cases: Smart Cities, ML-assisted diagnostics, Connected Vehicles, Interactive Live Video Streams, AR/VR, Real-time Gaming

AWS Local Zones

- Places AWS compute, storage, database, and other selected AWS services closer to end users to run latency-sensitive applications
- Extend your VPC to more locations – "Extension of an AWS Region"
- Compatible with EC2, RDS, ECS, EBS, ElastiCache, Direct Connect …
- Example:
    - AWS Region: N. Virginia (us-east-1)
    - AWS Local Zones: Boston, Chicago, Dallas, Houston, Miami

Global Applications - Summary

- Global DNS: Route 53
  - Great to route users to the closest deployment with least latency
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- Global Content Delivery Network (CDN): CloudFront
  - Replicate part of your application to AWS Edge Locations – decrease latency
  - Cache common requests – improved user experience and decreased latency
- S3 Transfer Acceleration
  - Accelerate global uploads & downloads into Amazon S3
- AWS Global Accelerator
  - Improve global application availability and performance using the AWS global network
- AWS Outposts
  - Deploy Outposts Racks in your own Data Centers to extend AWS services
- AWS WaveLength
  - Brings AWS services to the edge of the 5G networks
  - Ultra-low latency applications
- AWS Local Zones
  - Bring AWS resources (compute, database, storage, ...) closer to your users
  - Good for latency-sensitive applications

Cloud Integration

Section Introduction

- When we start deploying multiple applications, they will inevitably need to communicate with one another
- There are two patterns of application communication
  1. Synchronous communications (application to application)
  2. Asynchronous / Event based (application to queue to application)
- Synchronous between applications can be problematic if there are sudden spikes of traffic
- What if you need to suddenly encode 1000 videos but usually it's 10?
- In that case, it's better to **decouple** your applications:
  - using SQS: queue model
  - using SNS: pub/sub model
  - using Kinesis: real-time data streaming model (out of scope for the exam)
- These services can scale independently from our application!

Amazon SQS - Simple Queue Service

- Oldest AWS offering (over 10 years old)
- Fully managed service (~serverless), use to decouple applications
- Scales from 1 message per second to 10,000s per second
- Default retention of messages: 4 days, maximum of 14 days
- No limit to how many messages can be in the queue
- Messages are deleted after they're read by consumers
- Low latency (<10 ms on publish and receive)
- Consumers share the work to read messages & scale horizontally

Amazon Kinesis

- **Kinesis = real-time big data streaming**
- Managed service to collect, process, and analyze real-time streaming data at any scale
- Too detailed for the Cloud Practitioner exam but good to know:
    - Kinesis Data Streams: low latency streaming to ingest data at scale from hundreds of thousands of sources
    - Kinesis Data Firehose: load streams into S3, Redshift, ElasticSearch, etc...
    - Kinesis Data Analytics: perform real-time analytics on streams using SQL
    - Kinesis Video Streams: monitor real-time video streams for analytics or ML

Amazon SNS

- What if you want to send one message to many receivers?
- Amazon Simple Notification Service is a notification service provided as part of Amazon Web Services since 2010. It provides a low-cost infrastructure for mass delivery of messages, predominantly to mobile users.
- The "event publishers" only sends message to one SNS topic
- As many "event subscribers" as we want to listen to the SNS topic notifications
- Each subscriber to the topic will get all the messages
- Up to 12,500,000 subscriptions per topic, 100,000 topics limit

Amazon MQ

- SQS, SNS are "cloud-native" services, and they're using proprietary protocols from AWS.
- Traditional applications running from on-premise may use open protocols such as: MQTT, AMQP, STOMP, Openwire, WSS
- When migrating to the cloud, instead of re-engineering the application to use SQS and SNS, we can use Amazon MQ
- Amazon MQ = managed Apache ActiveMQ
- Amazon MQ doesn't "scale" as much as SQS / SNS
- Amazon MQ runs on a dedicated machine (not serverless)
- Amazon MQ has both queue feature (~SQS) and topic features (~SNS)

Integration - Summary

- SQS:
    - Queue service in AWS
    - Multiple Producers, messages are kept up to 14 days

    - Multiple Consumers share the read and delete messages when done
    - Used to decouple applications in AWS
- SNS:
    - Notification service in AWS
    - Subscribers: Email, Lambda, SQS, HTTP, Mobile...
    - Multiple Subscribers, send all messages to all of them
    - No message retention
- Kinesis: real-time data streaming, persistence and analysis
- Amazon MQ: managed Apache MQ in the cloud (MQTT, AMQP.. protocols)

Cloud Monitoring

Amazon CloudWatch

- CloudWatch provides metrics for every services in AWS
- Metric is a variable to monitor (CPUUtilization, NetworkIn, etc..)
- Metrics have timestamps
- Can create CloudWatch dashboards of metrics

Important Metrics

- EC2 instances: CPU Utilization, Status Checks, Network (not RAM)
    - Default metrics every 5 minutes
    - Option for Detailed Monitoring ($$$): metrics every 1 minute
- EBS volumes: Disk Read/Writes

- S3 buckets: BucketSizeBytes, NumberOfObjects, AllRequests
- Billing:Total Estimated Charge (only in us-east-1)
- Service Limits: how much you've been using a service API
- Custom metrics: push your own metrics

Amazon CloudWatch Alarms

- Alarms are used to trigger notifications for any metric
- Alarms actions...
    - Auto Scaling: increase or decrease EC2 instances "desired" count
    - EC2 Actions: stop, terminate, reboot or recover an EC2 instance
    - SNS notifications: send a notification into an SNS topic
- Various options (sampling, %, max, min, etc...)
- Can choose the period on which to evaluate an alarm
- Example: create a billing alarm on the CloudWatch Billing metric
- Alarm States: OK. INSUFFICIENT_DATA, ALARM

Amazon CloudWatch Logs

- CloudWatch Logs can collect log from:
    - Elastic Beanstalk: collection of logs from application
    - ECS: collection from containers
    - AWS Lambda: collection from function logs
    - CloudTrail based on filter
    - CloudWatch log agents: on EC2 machines or on-premises servers
    - Route53: Log DNS queries
- Enables real-time monitoring of logs
- Adjustable CloudWatch Logs retention

CloudWatch Logs for EC2

- By default, no logs from your EC2 instance will go to CloudWatch
- You need to run a CloudWatch agent on EC2 to push the log files you want
- Make sure IAM permissions are correct
- The CloudWatch log agent can be setup on-premises too

Amazon CloudWatch Events

- Schedule: Cron jobs (scheduled scripts)
    - Schedule Every hour => Trigger script on Lambda function
- Event Pattern: Event rules to react to a service doing something
    - IAM Root User Sign in Event => SNS Topic with Email Notification
- Trigger Lambda functions, send SQS/SNS messages

Amazon EventBridge

- EventBridge is the next evolution of CloudWatch Events
- Default event bus: generated by AWS services (CloudWatch Events)

- Partner event bus: receive events from SaaS service or applications (Zendesk, DataDog, Segment, Auth0...)
- Custom Event buses: for your own applications
- Schema Registry: model event schema
- EventBridge has a different name to mark the new capabilities
- The CloudWatch Events name will be replaced with EventBridge

AWS CloudTrail

- Provides governance, compliance and audit for your AWS Account
- CloudTrail is enabled by default!
- Get an history of events / API calls made within your AWS Account by:
    - Console
    - SDK
    - CLI
    - AWS Services
- Can put logs from CloudTrail into CloudWatch Logs or S3
- A trail can be applied to All Regions (default) or a single Region.
- If a resource is deleted in AWS, investigate CloudTrail first!

CloudTrail Events

- Management Events:
    - Operations that are performed on resources in your AWS account
    - Examples:
        - Configuring security (IAM AttachRolePolicy)
        - Configuring rules for routing data (Amazon EC2 CreateSubnet)
        - Setting up logging (AWS CloudTrail CreateTrail)
    - By default, trails are configured to log management events.
    - Can separate Read Events (that don't modify resources) from Write Events (that may modify resources)
- Data Events:
    - By default, data events are not logged (because high volume operations)
    - Amazon S3 object-level activity (ex: GetObject, DeleteObject, PutObject): can separate Read and Write Events
    - AWS Lambda function execution activity (the Invoke API)

CloudTrail Insights Events

- Enable CloudTrail Insights to detect unusual activity in your account:
    - inaccurate resource provisioning
    - hitting service limits
    - Bursts of AWS IAM actions
    - Gaps in periodic maintenance activity
- CloudTrail Insights analyzes normal management events to create a baseline
- And then continuously analyzes write events to detect unusual patterns
    - Anomalies appear in the CloudTrail console
    - Event is sent to Amazon S3

    - An EventBridge event is generated (for automation needs)

CloudTrail Events Retention

- Events are stored for 90 days in CloudTrail
- To keep events beyond this period, log them to S3 and use Athena

AWS X-Ray

- Debugging in Production, the good old way:
    - Test locally
    - Add log statements everywhere
    - Re-deploy in production
- Log formats differ across applications and log analysis is hard.
- Debugging: one big monolith “easy”, distributed services “hard”
- No common views of your entire architecture

AWS X-Ray advantages

- Troubleshooting performance (bottlenecks)
- Understand dependencies in a microservice architecture
- Pinpoint service issues
- Review request behavior
- Find errors and exceptions
- Are we meeting time SLA?
- Where I am throttled?
- Identify users that are impacted

Amazon CodeGuru

- An ML-powered service for automated code reviews and application performance recommendations
- Provides two functionalities
- CodeGuru Reviewer: automated code reviews for static code analysis (development)
- CodeGuru Profiler: visibility/recommendations about application performance during runtime (production)

Amazon CodeGuru Reviewer

- Identify critical issues, security vulnerabilities, and hard-to-find bugs
- Example: common coding best practices, resource leaks, security detection, input validation
- Uses Machine Learning and automated reasoning
- Hard-learned lessons across millions of code reviews on 1000s of open-source and Amazon repositories
- Supports Java and Python
- Integrates with GitHub, Bitbucket, and AWS CodeCommit

Amazon CodeGuru Profiler

- Helps understand the runtime behavior of your application

- Example: identify if your application is consuming excessive CPU capacity on a logging routine
- Features:
  - Identify and remove code inefficiencies
  - Improve application performance (e.g., reduce CPU utilization)
  - Decrease compute costs
  - Provides heap summary (identify which objects using up memory)
  - Anomaly Detection
- Support applications running on AWS or on- premise
- Minimal overhead on application

AWS Status - Service Health Dashboard

- Shows all regions, all services health
- Shows historical information for each day
- Has an RSS feed you can subscribe to
- https://status.aws.amazon.com/

AWS Personal Health Dashboard

- AWS Personal Health Dashboard provides alerts and remediation guidance when AWS is experiencing events that may impact you.
- While the Service Health Dashboard displays the general status of AWS services, Personal Health Dashboard gives you a personalized view into the performance and availability of the AWS services underlying your AWS resources.
- The dashboard displays relevant and timely information to help you manage events in progress and provides proactive notification to help you plan for scheduled activities.
- Global service https://phd.aws.amazon.com/
- Shows how AWS outages directly impact you & your AWS resources
- Alert, remediation, proactive, scheduled activities

Cloud Monitoring Summary

- CloudWatch:
  - Metrics: monitor the performance of AWS services and billing metrics
  - Alarms: automate notification, perform EC2 action, notify to SNS based on metric
  - Logs: collect log files from EC2 instances, servers, Lambda functions…
  - Events (or EventBridge): react to events in AWS, or trigger a rule on a schedule
- CloudTrail: audit API calls made within your AWS account
- CloudTrail Insights: automated analysis of your CloudTrail Events
- X-Ray: trace requests made through your distributed applications
- Service Health Dashboard: status of all AWS services across all regions
- Personal Health Dashboard: AWS events that impact your infrastructure
- Amazon CodeGuru: automated code reviews and application performance recommendations

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VPC

VPC & Subnets Primer

- VPC -Virtual Private Cloud: private network to deploy your resources (regional resource)
- Subnets allow you to partition your network inside your VPC (Availability Zone resource)
- A public subnet is a subnet that is accessible from the internet
- A private subnet is a subnet that is not accessible from the internet
- To define access to the internet and between subnets, we use Route Tables.

Internet Gateway & NAT Gateways

- Internet Gateways helps our VPC instances connect with the internet
- Public Subnets have a route to the internet gateway.
- NAT Gateways (AWS-managed) & NAT Instances (self-managed) allow your instances in your Private Subnets to access the internet while remaining private

Network ACL & Security Groups

- NACL (Network ACL)
  - A firewall which controls traffic from and to subnet
  - Can have ALLOW and DENY rules
  - Are attached at the Subnet level
  - Rules only include IP addresses
- Security Groups
  - A firewall that controls traffic to and from an ENI / an EC2 Instance
  - Can have only ALLOW rules
  - Rules include IP addresses and other security groups

Network ACLs vs Security Groups

Security Group	**Network ACL**
Operates at the instance level	Operates at the subnet level
Supports allow rules only	Supports allow rules and deny rules
Is stateful: Return traffic is automatically allowed, regardless of any rules	Is stateless: Return traffic must be explicitly allowed by rules

Security Group	Network ACL
We evaluate all rules before deciding whether to allow traffic	We process rules in number order when deciding whether to allow traffic
Applies to an instance only if someone specifies the security group when launching the instance, or associates the security group with the instance later on	Automatically applies to all instances in the subnets it's associated with (therefore, you don't have to rely on users to specify the security group)

https://docs.aws.amazon.com/vpc/latest/userguide/VPC_Security.html

VPC Flow Logs

- Capture information about IP traffic going into your interfaces:
  - VPC Flow Logs
  - Subnet Flow Logs
  - Elastic Network Interface Flow Logs
- Helps to monitor & troubleshoot connectivity issues. Example:
  - Subnets to internet
  - Subnets to subnets
  - Internet to subnets
- Captures network information from AWS managed interfaces too: Elastic Load Balancers, ElastiCache, RDS, Aurora, etc...
- VPC Flow logs data can go to S3 / CloudWatch Logs

VPC Peering

- Connect two VPC, privately using AWS' network
- Make them behave as if they were in the same network
- Must not have overlapping CIDR (IP address range)
- VPC Peering connection is not transitive (must be established for each VPC that need to communicate with one another)

VPC Endpoints

- Endpoints allow you to connect to AWS Services using a private network instead of the public www network
- This gives you enhanced security and lower latency to access AWS services
- VPC Endpoint Gateway: S3 & DynamoDB
- VPC Endpoint Interface: the rest

Site to Site VPN & Direct Connect

- Site to Site VPN
  - Connect an on-premises VPN to AWS
  - The connection is automatically encrypted
  - Goes over the public internet
  - On-premises: must use a Customer Gateway (CGW)

    - AWS: must use a Virtual Private Gateway (VGW)
- Direct Connect (DX)
    - Establish a physical connection between on-premises and AWS
    - The connection is private, secure and fast
    - Goes over a private network
    - Takes at least a month to establish

Transit Gateway

- For having transitive peering between thousands of VPC and on-premises, hub-and-spoke (star) connection
- One single Gateway to provide this functionality
- Works with Direct Connect Gateway, VPN connections

VPC Summary

- VPC: Virtual Private Cloud
- Subnets:Tied to an AZ, network partition of the VPC
- Internet Gateway: at the VPC level, provide Internet Access
- NAT Gateway / Instances: give internet access to private subnets
- NACL: Stateless, subnet rules for inbound and outbound
- Security Groups: Stateful, operate at the EC2 instance level or ENI
- VPC Peering: Connect two VPC with non overlapping IP ranges, nontransitive
- VPC Endpoints: Provide private access to AWS Services within VPC
- VPC Flow Logs: network traffic logs
- Site to Site VPN: VPN over public internet between on-premises DC and AWS
- Direct Connect: direct private connection to AWS
- Transit Gateway: Connect thousands of VPC and on-premises networks together

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Security and Compliance

- Security & Compliance
    - AWS Shared Responsibility Model
        - Example, for RDS
        - Example, for S3
    - DDOS Protection on AWS
    - AWS Shield
    - AWS WAF - Web Application Firewall
    - Penetration Testing on AWS Cloud
    - Data at rest vs. Data in transit
    - AWS KMS (Key Management Service)
    - CloudHSM
    - Types of Customer Master Keys: CMK
        - Customer Managed CMK
        - AWS managed CMK
        - AWS owned CMK

AWS Shared Responsibility Model

- AWS responsibility - Security of the Cloud
    - Protecting infrastructure (hardware, software, facilities, and networking) that runs all the AWS services
    - Managed services like S3, DynamoDB, RDS, etc.
- Customer responsibility - Security in the Cloud
    - For EC2 instance, customer is responsible for management of the guest OS (including security patches and updates), firewall & network configuration, IAM
    - Encrypting application data
- Shared controls:
    - Patch Management, Configuration Management, Awareness & Training

Example, for RDS

- AWS responsibility:
    - Manage the underlying EC2 instance, disable SSH access
    - Automated DB patching
    - Automated OS patching
    - Audit the underlying instance and disks & guarantee it functions
- Your responsibility:
    - Check the ports / IP / security group inbound rules in DB's SG
    - In-database user creation and permissions
    - Creating a database with or without public access
    - Ensure parameter groups or DB is configured to only allow SSL connections
    - Database encryption setting

Example, for S3

- AWS responsibility:
    - Guarantee you get unlimited storage
    - Guarantee you get encryption
    - Ensure separation of the data between different customers

    - Ensure AWS employees can't access your data
- Your responsibility:
    - Bucket configuration
    - Bucket policy / public setting
    - IAM user and roles
    - Enabling encryption

DDOS Protection on AWS

- **AWS Shield Standard**: protects against DDOS attack for your website and applications, for all customers at no additional costs
- **AWS Shield Advanced**: 24/7 premium DDoS protection
- **AWS WAF**: Filter specific requests based on rules
- **CloudFront and Route 53**:
    - Availability protection using global edge network
    - Combined with AWS Shield, provides attack mitigation at the edge
- Be ready to scale – leverage **AWS Auto Scaling**

AWS Shield

- AWS Shield Standard:
    - Free service that is activated for every AWS customer
    - Provides protection from attacks such as SYN/UDP Floods, Reflection attacks and other layer 3/layer 4 attacks
- AWS Shield Advanced:
    - Optional DDoS mitigation service ($3,000 per month per organization)
    - Protect against more sophisticated attack on Amazon EC2, Elastic Load Balancing (ELB), Amazon CloudFront, AWS Global Accelerator, and Route 53
    - 24/7 access to AWS DDoS response team (DRP)
    - Protect against higher fees during usage spikes due to DDoS

AWS WAF - Web Application Firewall

- Protects your web applications from common web exploits (Layer 7)
- Layer 7 is HTTP (vs Layer 4 is TCP)
- Deploy on **Application Load Balancer, API Gateway, CloudFront**
- Define Web ACL (Web Access Control List):
    - Rules can include IP addresses, HTTP headers, HTTP body, or URI strings
    - Protects from common attack - SQL injection and Cross-Site Scripting (XSS)
    - Size constraints, geo-match (block countries)
    - Rate-based rules (to count occurrences of events) – for DDoS protection

Penetration Testing on AWS Cloud

- AWS customers are welcome to carry out security assessments or penetration tests against their AWS infrastructure without prior approval for 8 services:
    - Amazon EC2 instances, NAT Gateways, and Elastic Load Balancers
    - Amazon RDS

    - Amazon CloudFront
    - Amazon Aurora
    - Amazon API Gateways
    - AWS Lambda and Lambda Edge functions
    - Amazon Lightsail resources
    - Amazon Elastic Beanstalk environments
- List can increase over time
- Prohibited Activities
    - DNS zone walking via Amazon Route 53 Hosted Zones
    - Denial of Service (DoS), Distributed Denial of Service (DDoS), Simulated DoS, Simulated DDoS
    - Port flooding
    - Protocol flooding
    - Request flooding (login request flooding, API request flooding)
- For any other simulated events, contact aws-security-simulatedevent@amazon.com
- Read more: https://aws.amazon.com/security/penetration-testing/

Data at rest vs. Data in transit

- At rest: data stored or archived on a device
    - On a hard disk, on a RDS instance, in S3 Glacier Deep Archive, etc.
- In transit (in motion): data being moved from one location to another
    - Transfer from on-premises to AWS, EC2 to DynamoDB, etc.
    - Means data transferred on the network
- We want to encrypt data in both states to protect it!
- For this we leverage encryption keys

AWS KMS (Key Management Service)

- Anytime you hear “encryption” for an AWS service, it’s most likely KMS
- KMS = AWS manages the encryption keys for us
- Encryption Opt-in:
    - EBS volumes: encrypt volumes
    - S3 buckets: Server-side encryption of objects
    - Redshift database: encryption of data
    - RDS database: encryption of data
    - EFS drives: encryption of data
- Encryption Automatically enabled:
    - CloudTrail Logs
    - S3 Glacier
    - Storage Gateway

CloudHSM

- KMS => AWS manages the software for encryption
- CloudHSM => AWS provisions encryption hardware
- Dedicated Hardware (HSM = Hardware Security Module)
- You manage your own encryption keys entirely (not AWS)
- HSM device is tamper resistant, FIPS 140-2 Level 3 compliance

Types of Customer Master Keys: CMK

Customer Managed CMK

- Create, manage and used by the customer, can enable or disable
- Possibility of rotation policy (new key generated every year, old key preserved)
- Possibility to bring-your-own-key

AWS managed CMK

- Created, managed and used on the customer's behalf by AWS
- Used by AWS services (aws/s3, aws/ebs, aws/redshift)

AWS owned CMK

- Collection of CMKs that an AWS service owns and manages to use in multiple accounts
- AWS can use those to protect resources in your account (but you can't view the keys)

CloudHSM Keys (custom keystore)

- Keys generated from your own CloudHSM hardware device
- Cryptographic operations are performed within the CloudHSM cluster

AWS Certificate Manager (ACM)

- Let's you easily provision, manage, and deploy **SSL/TLS Certificates**
- Used to provide in-flight encryption for websites (HTTPS)
- Supports both public and private TLS certificates
- Free of charge for public TLS certificates
- Automatic TLS certificate renewal
- Integrations with (load TLS certificates on)
    - Elastic Load Balancers
    - CloudFront Distributions
    - APIs on API Gateway

AWS Secrets Manager

- Newer service, meant for storing secrets
- Capability to force rotation of secrets every X days
- Automate generation of secrets on rotation (uses Lambda)
- Integration with Amazon RDS (MySQL, PostgreSQL, Aurora)
- Secrets are encrypted using KMS
- Mostly meant for RDS integration

AWS Artifact (not really a service)

- Portal that provides customers with on-demand access to AWS compliance documentation and AWS agreements
- **Artifact Reports** - Allows you to download AWS security and compliance documents from third-party auditors, like AWS ISO certifications, Payment Card Industry (PCI), and System and Organization Control

(SOC) reports
- **Artifact Agreements** - Allows you to review, accept, and track the status of AWS agreements such as the Business Associate Addendum (BAA) or the Health Insurance Portability and Accountability Act (HIPAA) for an individual account or in your organization
- Can be used to support internal audit or compliance

Amazon GuardDuty

- Intelligent Threat discovery to Protect AWS Account
- Uses Machine Learning algorithms, anomaly detection, 3rd party data
- One click to enable (30 days trial), no need to install software
    - Input data includes:
    - CloudTrail Events Logs – unusual API calls, unauthorized deployments
        - CloudTrail Management Events – create VPC subnet, create trail, …
        - CloudTrail S3 Data Events – get object, list objects, delete object, …
    - VPC Flow Logs – unusual internal traffic, unusual IP address
    - DNS Logs – compromised EC2 instances sending encoded data within DNS queries
    - Kubernetes Audit Logs – suspicious activities and potential EKS cluster compromises
- Can setup CloudWatch Event rules to be notified in case of findings
- CloudWatch Events rules can target AWS Lambda or SNS
- Can protect against CryptoCurrency attacks (has a dedicated “finding” for it)

Amazon Inspector

- Automated Security Assessments
- For EC2 instances
    - Leveraging the AWS System Manager (SSM) agent
    - Analyze against unintended network accessibility
    - Analyze the running OS against known vulnerabilities
- For Containers push to Amazon ECR
    - Assessment of containers as they are pushed
- Reporting & integration with AWS Security Hub
- Send findings to Amazon Event Bridge

What does AWS Inspector evaluate?

- Remember: only for EC2 instances and container infrastructure
- Continuous scanning of the infrastructure, only when needed
- Package vulnerabilities (EC2 & ECR) – database of CVE
- Network reachability (EC2)
- A risk score is associated with all vulnerabilities for prioritization

AWS Config

- Helps with auditing and recording compliance of your AWS resources
- Helps record configurations and changes over time
- Possibility of storing the configuration data into S3 (analyzed by Athena)
- Questions that can be solved by AWS Config:

    - Is there unrestricted SSH access to my security groups?
    - Do my buckets have any public access?
    - How has my ALB configuration changed over time?
- You can receive alerts (SNS notifications) for any changes
- AWS Config is a per-region service
- Can be aggregated across regions and accounts
- **View compliance of a resource over time**
- **View configuration of a resource over time**
- **View CloudTrail API calls if enabled**

Amazon Macie

- Amazon Macie is a fully managed data security and data privacy service that uses machine learning and pattern matching to discover and protect your sensitive data in AWS.
- Macie helps identify and alert you to sensitive data, such as personally identifiable information (PII)

AWS Security Hub

- Central security tool to manage security across several AWS accounts and automate security checks
- Integrated dashboards showing current security and compliance status to quickly take actions
- Automatically aggregates alerts in predefined or personal findings formats from various AWS services & AWS partner tools:
    - GuardDuty
    - Inspector
    - Macie
    - IAM Access Analyzer
    - AWS Systems Manager
    - AWS Firewall Manager
    - AWS Partner Network Solutions
- Must first enable the AWS Config Service

Amazon Detective

- GuardDuty, Macie, and Security Hub are used to identify potential security issues, or findings
- Sometimes security findings require deeper analysis to isolate the root cause and take action – it's a complex process
- Amazon Detective **analyzes, investigates, and quickly identifies the root cause of security issues or suspicious activities (using ML and graphs)**
- **Automatically collects and processes events** from VPC Flow Logs, CloudTrail, GuardDuty and create a unified view

AWS Abuse

- Report suspected AWS resources used for abusive or illegal purposes
- Abusive & prohibited behaviors are:
    - Spam – receiving undesired emails from AWS-owned IP address, websites & forums spammed by AWS resources
    - Port scanning – sending packets to your ports to discover the unsecured ones

    - DoS or DDoS attacks – AWS-owned IP addresses attempting to overwhlem or crash your servers/softwares
    - Intrusion attempts – logging in on your resources
    - Hosting objectionable or copyrighted content – distributing illegal or copyrighted content without consent
    - Distributing malware – AWS resources distributing softwares to harm computers or machines
- Contact the AWS Abuse team: AWS abuse form, or abuse@amazonaws.com

Root user privileges

- Root user = Account Owner (created when the account is created)
- Has complete access to all AWS services and resources
- Lock away your AWS account root user access keys!
- Do not use the root account for everyday tasks, even administrative tasks
- **Actions that can be performed only by the root user:**
    - Change account settings (account name, email address, root user password, root user access keys)
    - View certain tax invoices
    - Close your AWS account
    - Restore IAM user permissions
    - Change or cancel your AWS Support plan
    - Register as a seller in the Reserved Instance Marketplace
    - Configure an Amazon S3 bucket to enable MFA
    - Edit or delete an Amazon S3 bucket policy that includes an invalid VPC ID or VPC endpoint ID
    - Sign up for GovCloud

Summary

- Shared Responsibility on AWS
- Shield: Automatic DDoS Protection + 24/7 support for advanced
- WAF: Firewall to filter incoming requests based on rules
- KMS: Encryption keys managed by AWS
- CloudHSM: Hardware encryption, we manage encryption keys
- AWS Certificate Manager: provision, manage, and deploy SSL/TLS Certificates
- Artifact: Get access to compliance reports such as PCI, ISO, etc...
- GuardDuty: Find malicious behavior with VPC, DNS & CloudTrail Logs
- Inspector: For EC2 only, install agent and find vulnerabilities
- Config: Track config changes and compliance against rules
- Macie: Find sensitive data (ex: PII data) in Amazon S3 buckets
- CloudTrail: Track API calls made by users within account
- AWS Security Hub: gather security findings from multiple AWS accounts
- Amazon Detective: find the root cause of security issues or suspicious activities
- AWS Abuse: Report AWS resources used for abusive or illegal purposes
- Root user privileges:
    - Change account settings
    - Close your AWS account
    - Change or cancel your AWS Support plan

    - Register as a seller in the Reserved Instance Marketplace

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Machine Learning

Amazon Rekognition

- Find **objects, people, text, scenes** in **images and videos** using ML
- Facial analysis and facial search to do user verification, people counting
- Create a database of “familiar faces” or compare against celebrities
- Use cases:
- Labeling
    - Content Moderation
    - Text Detection
    - Face Detection and Analysis (gender, age range, emotions...)
    - Face Search and Verification
    - Celebrity Recognition
- https://aws.amazon.com/rekognition/

Amazon Transcribe

- Automatically **convert speech to text**
- Uses a deep learning process called automatic speech recognition (ASR) to convert speech to text quickly and accurately
- Use cases:
    - transcribe customer service calls
    - automate closed captioning and subtitling
    - generate metadata for media assets to create a fully searchable archive

Amazon Polly

- Turn **text into lifelike speech** using deep learning
- Allowing you to create applications that talk

Amazon Translate

- Natural and accurate **language translation**
- Amazon Translate allows you to localize content - such as websites and applications - for international users, and to easily translate large volumes of text efficiently.

Amazon Lex & Connect

Amazon Lex: (same technology that powers Alexa)

- Automatic Speech Recognition (ASR) to convert speech to text
- Natural Language Understanding to recognize the intent of text, callers
- Helps build chatbot, call center bots

Amazon Connect

- Receive calls, create contact flows, cloud-based virtual contact center
- Can integrate with other CRM systems or AWS
- No upfront payments, 80% cheaper than traditional contact center solutions

Amazon Comprehend

- For **Natural Language Processing – NLP**
- Fully managed and serverless service
- Uses machine learning to find insights and relationships in text
    - Language of the text
    - Extracts key phrases, places, people, brands, or events
    - Understands how positive or negative the text is
    - Analyzes text using tokenization and parts of speech
    - Automatically organizes a collection of text files by topic
- Sample use cases:
    - analyze customer interactions (emails) to find what leads to a positive or negative experience
    - Create and groups articles by topics that Comprehend will uncover

Amazon SageMaker

- Fully managed service for **developers / data scientists to build ML models**
- Typically, difficult to do all the processes in one place + provision servers
- Machine learning process (simplified): predicting your exam score

Amazon Forecast

- Fully managed service that uses ML to deliver highly accurate forecasts
- Example: predict the future sales of a raincoat
- 50% more accurate than looking at the data itself
- Reduce forecasting time from months to hours

- Use cases: Product Demand Planning, Financial Planning, Resource Planning,etc..

Amazon Kendra

- Fully managed document search service powered by Machine Learning
- Extract answers from within a document (text, pdf, HTML, PowerPoint, MS Word, FAQs...)
- Natural language search capabilities
- Learn from user interactions/feedback to promote preferred results (Incremental Learning)
- Ability to manually fine-tune search results (importance of data, freshness, custom,etc..)

Amazon Personalize

- Fully managed ML-service to build apps with real-time personalized recommendations
- Example: personalized product recommendations/re-ranking, customized direct marketing
    - Example: User bought gardening tools, provide recommendations on the next one to buy
- Same technology used by Amazon.com
- Integrates into existing websites, applications, SMS, email marketing systems, ...
- Implement in days, not months (you don't need to build, train, and deploy ML solutions)
- Use cases: retail stores, media and entertainment

Amazon Textract

- Automatically extracts text, handwriting, and data from any scanned documents using AI and ML
- Extract data from forms and tables
- Read and process any type of document (PDFs, images, ...)
- Use cases:
    - Financial Services (e.g., invoices, financial reports)
    - Healthcare (e.g., medical records, insurance claims)
    - Public Sector (e.g., tax forms, ID documents, passports)

Summary

- Rekognition: face detection, labeling, celebrity recognition
- Transcribe: audio to text (ex: subtitles)
- Polly: text to audio
- Translate: translations
- Lex: build conversational bots – chatbot
- Connect: cloud contact center
- Comprehend: natural language processing
- SageMaker: machine learning for every developer and data scientist
- Forecast: build highly accurate forecasts
- Kendra: ML-powered search engine
- Personalize: real-time personalized recommendations
- Textract: detect text and data in documents

Account Management Billing and Support

AWS Organizations

- Global service
- Allows to manage **multiple AWS accounts**
- The main account is the master account
- Cost Benefits:
  - Consolidated Billing across all accounts - single payment method
  - Pricing benefits from aggregated usage (volume discount for EC2, S3...)
  - Pooling of Reserved EC2 instances for optimal savings
- API is available to **automate AWS account creation**
- Restrict account privileges using Service Control Policies (SCP)

Multi Account Strategies

- Create accounts per **department**, per **cost center**, per **dev / test / prod**, based on regulatory restrictions (using SCP), for better resource isolation (ex: VPC), to have separate per-account service limits, isolated account for logging
- Multi Account vs One Account Multi VPC
- Use tagging standards for billing purposes
- Enable CloudTrail on all accounts, send logs to central S3 account
- Send CloudWatch Logs to central logging account

Service Control Policies (SCP)

- Whitelist or blacklist IAM actions
- Applied at the OU or Account level
- Does not apply to the Master Account
- SCP is applied to all the Users and Roles of the Account, including Root user
- The SCP does not affect service-linked roles
    - Service-linked roles enable other AWS services to integrate with AWS Organizations and can't be restricted by SCPs.
- SCP must have an explicit Allow (does not allow anything by default)
- Use cases:
    - Restrict access to certain services (for example: can’t use EMR)
    - Enforce PCI compliance by explicitly disabling services

AWS Organization - Consolidated Billing

- When enabled, provides you with:
    - Combined Usage – combine the usage across all AWS accounts in the AWS Organization to share the volume pricing, Reserved Instances and Savings Plans discounts
    - One Bill – get one bill for all AWS Accounts in the AWS Organization
- The management account can turn off Reserved Instances discount sharing for any account in the AWS Organization, including itself

AWS Control Tower

- Easy way to set up and govern a secure and compliant multi-account AWS environment based on best practices
- Benefits:
    - Automate the set up of your environment in a few clicks
    - Automate ongoing policy management using guardrails
    - Detect policy violations and remediate them
    - Monitor compliance through an interactive dashboard
- AWS Control Tower runs on top of AWS Organizations:
    - It automatically sets up AWS Organizations to organize accounts and implement SCPs (Service Control Policies)

Pricing Models in AWS

- AWS has 4 pricing models:
- **Pay as you go**: pay for what you use, remain agile, responsive, meet scale demands
- **Save when you reserve**: minimize risks, predictably manage budgets, comply with long-terms requirements
    - Reservations are available for EC2 Reserved Instances, DynamoDB Reserved Capacity, ElastiCache Reserved Nodes, RDS Reserved Instance, Redshift Reserved Nodes
- **Pay less by using more**: volume-based discounts
- **Pay less as AWS grows**

Compute Pricing

EC2

- Only charged for what you use
- Number of instances
- Instance configuration:
    - Physical capacity
    - Region
    - OS and software
    - Instance type
    - Instance size
- ELB running time and amount of data processed
- Detailed monitoring
- On-demand instances:
    - Minimum of 60s
    - Pay per second (Linux/Windows) or per hour (other)
- Reserved instances:
    - Up to 75% discount compared to On-demand on hourly rate
    - 1- or 3-years commitment
    - All upfront, partial upfront, no upfront
- Spot instances:
    - Up to 90% discount compared to On-demand on hourly rate
    - Bid for unused capacity
- Dedicated Host:
    - On-demand
    - Reservation for 1 year or 3 years commitment
    - Savings plans as an alternative to save on sustained usage

Lambda & ECS

- Lambda:
  - Pay per call
  - Pay per duration
- ECS:
  - EC2 Launch Type Model: No additional fees, you pay for AWS resources stored and created in your application
- Fargate:
  - Fargate Launch Type Model: Pay for vCPU and memory resources allocated to your applications in your containers

Storage Pricing

S3

- Storage class: S3 Standard, S3 Infrequent Access, S3 One-Zone IA, S3 Intelligent Tiering, S3 Glacier and S3 Glacier Deep Archive
- Number and size of objects: Price can be tiered (based on volume)
- Number and type of requests
- Data transfer OUT of the S3 region
- S3 Transfer Acceleration
- Lifecycle transitions
- Similar service: EFS (pay per use, has infrequent access & lifecycle rules)

EBS

- Volume type (based on performance)
- Storage volume in GB per month provisioned
- IOPS:
  - General Purpose SSD: Included
  - Provisioned IOPS SSD: provisioned amount in IOPS
  - Magnetic: Number of requests
- Snapshots:
  - Added data cost per GB per month
- Data transfer:
  - Outbound data transfer are tiered for volume discounts
  - Inbound is free

Database Pricing - RDS

- Per hour billing
- Database characteristics:
  - Engine
  - Size
  - Memory class
- Purchase type:
  - On-demand
  - Reserved instances (1 or 3 years) with required up-front

- Backup Storage: There is no additional charge for backup storage up to 100% of your total database storage for a region.
- Additional storage (per GB per month)
- Number of input and output requests per month
- Deployment type (storage and I/O are variable):
    - Single AZ
    - Multiple AZs
- Data transfer:
    - Outbound data transfer are tiered for volume discounts
    - Inbound is free

Content Delivery - CloudFront

- Pricing is different across different geographic regions
- Aggregated for each edge location, then applied to your bill
- Data Transfer Out (volume discount)
- Number of HTTP/HTTPS requests

Networking Costs in AWS per GB - Simplified

- Use Private IP instead of Public IP for good savings and better network performance
- Use same AZ for maximum savings (at the cost of high availability)

Savings Plan

- Commit a certain $ amount per hour for 1 or 3 years
- Easiest way to setup long-term commitments on AWS
- EC2 Savings Plan
    - Up to 72% discount compared to On-Demand
    - Commit to usage of individual instance families in a region (e.g. C5 or M5)
    - Regardless of AZ, size (m5.xl to m5.4xl), OS (Linux/Windows) or tenancy
    - All upfront, partial upfront, no upfront
- Compute Savings Plan
    - Up to 66% discount compared to On-Demand
    - Regardless of Family, Region, size, OS, tenancy, compute options
    - Compute Options: EC2, Fargate, Lambda
- Setup from the AWS Cost Explorer console
- Estimate pricing at https://aws.amazon.com/savingsplans/pricing/

AWS Compute Optimizer

- Reduce costs and improve performance by recommending optimal AWS resources for your workloads
- Helps you choose optimal configurations and right - size your workloads (over/under provisioned)
- Uses Machine Learning to analyze your resources' configurations and their utilization CloudWatch metrics
- Supported resources
    - EC2 instances
    - EC2 Auto Scaling Groups

    - EBS volumes
    - Lambda functions
- Lower your costs by up to 25%
- Recommendations can be exported to S3

Billing and Costing Tools

- Estimating costs in the cloud:
    - Pricing Calculator
- Tracking costs in the cloud:
    - Billing Dashboard
    - Cost Allocation Tags
    - Cost and Usage Reports
    - Cost Explorer
- Monitoring against costs plans:
    - Billing Alarms
    - Budgets

AWS Pricing Calculator

- Available at https://calculator.aws/
- Estimate the cost for your solution architecture

Cost Allocation Tags

- Use cost allocation tags to track your AWS costs on a detailed level
- AWS generated tags
    - Automatically applied to the resource you create
    - Starts with Prefix aws: (e.g. aws: createdBy)
- User-defined tags
    - Defined by the user
    - Starts with Prefix user:

Tagging and Resource Groups

- Tags are used for organizing resources:
    - EC2: instances, images, load balancers, security groups…
    - RDS, VPC resources, Route 53, IAM users, etc…
    - Resources created by CloudFormation are all tagged the same way
- Free naming, common tags are: Name, Environment, Team …
- Tags can be used to create **Resource Groups**
    - Create, maintain, and view a collection of resources that share common tags
    - Manage these tags using the Tag Editor

Cost and Usage Reports

- Dive deeper into your AWS costs and usage

- The AWS Cost & Usage Report contains the most comprehensive set of AWS cost and usage data available, including additional metadata about AWS services, pricing, and reservations (e.g., Amazon EC2 Reserved Instances (RIs)).
- The AWS Cost & Usage Report lists AWS usage for each service category used by an account and its IAM users in hourly or daily line items, as well as any tags that you have activated for cost allocation purposes.
- Can be integrated with Athena, Redshift or QuickSight

Cost Explorer

- Visualize, understand, and manage your AWS costs and usage over time
- Create custom reports that analyze cost and usage data.
- Analyze your data at a high level: total costs and usage across all accounts
- Or Monthly, hourly, resource level granularity
- Choose an optimal **Savings Plan**(to lower prices on your bill)
- **Forecast usage up to 12 months based on previous usage**
- Cost Explorer – Monthly Cost by AWS Service
- Cost Explorer– Hourly & Resource Level
- Cost Explorer – Savings Plan Alternative to Reserved Instances
- Cost Explorer – Forecast Usage

Billing Alarms in CloudWatch

- Billing data metric is stored in CloudWatch us-east1
- Billing data are for overall worldwide AWS costs
- It's for actual cost, not for projected costs
- Intended a simple alarm (not as powerful as AWS Budgets)

AWS Budgets

- Create budget and send alarms when costs exceeds the budget
- 3 types of budgets: Usage, Cost, Reservation
- For Reserved Instances (RI)
    - Track utilization
    - Supports EC2, ElastiCache, RDS, Redshift
- Up to 5 SNS notifications per budget
- Can filter by: Service, Linked Account, Tag, Purchase Option, Instance Type, Region, Availability Zone, API Operation, etc…
- Same options as AWS Cost Explorer!
- 2 budgets are free, then $0.02/day/budget

Trusted Advisor

- No need to install anything – high level AWS account assessment
- Analyze your AWS accounts and provides recommendation on 5 categories
- Cost optimization
- Performance
- Security
- Fault tolerance
- Service limits

Trusted Advisor - Support Plans

7 CORE CHECKS Basic & Developer Support plan	**FULL CHECKS Business & Enterprise Support plan**
S3 Bucket Permissions, Security Groups – Specific Ports Unrestricted	Full Checks available on the 5 categories
IAM Use (one IAM user minimum), MFA on Root Account	Ability to set CloudWatch alarms when reaching limits
EBS Public Snapshots, RDS Public Snapshots, Service Limits	Programmatic Access using AWS Support API

AWS Basic Support Plan

- Customer Service & Communities - 24x7 access to customer service, documentation, whitepapers, and support forums.
- AWS Trusted Advisor - Access to the 7 core Trusted Advisor checks and guidance to provision your resources following best practices to increase performance and improve security.
- AWS Personal Health Dashboard - A personalized view of the health of AWS services, and alerts when your resources are impacted.

AWS Developer Support Plan

- All Basic Support Plan +
- Business hours email access to Cloud Support Associates
- Unlimited cases / 1 primary contact
- Case severity / response times:
    - General guidance: < 24 business hours
    - System impaired: < 12 business hours

AWS Business Support Plan (24/7)

- Intended to be used if you have production workloads
- Trusted Advisor – Full set of checks + API access
- 24x7 phone, email, and chat access to Cloud Support Engineers
- Unlimited cases / unlimited contacts
- Access to Infrastructure Event Management for additional fee.
- Case severity / response times:
    - General guidance: < 24 business hours

    - System impaired: < 12 business hours
    - Production system impaired: < 4 hours
    - Production system down: < 1 hour

AWS Enterprise On-Ramp Support Plan (24/7)

- Intended to be used if you have production or business critical workloads
- All of Business Support Plan +
- Access to a pool of Technical Account Managers (TAM)
- Concierge Support Team (for billing and account best practices)
- Infrastructure Event Management, Well-Architected & Operations Reviews
- Case severity / response times:
    - Production system impaired: < 4 hours
    - Production system down: < 1 hour
    - Business-critical system down: < 30 minutes

AWS Enterprise Support Plan (24/7)

- Intended to be used if you have mission critical workloads
- All of Business Support Plan +
- Access to a designated Technical Account Manager (TAM)
- Concierge Support Team (for billing and account best practices)
- Infrastructure Event Management, Well-Architected & Operations Reviews
- Case severity / response times:
    - Production system impaired: < 4 hours
    - Production system down: < 1 hour
    - Business-critical system down: < 15 minutes

Account Best Practices - Summary

- Operate multiple accounts using Organizations
- Use SCP (service control policies) to restrict account power
- Easily setup multiple accounts with best-practices with AWS Control Tower
- Use Tags & Cost Allocation Tags for easy management & billing
- IAM guidelines: MFA, least-privilege, password policy, password rotation
- Config to record all resources configurations & compliance over time
- CloudFormation to deploy stacks across accounts and regions
- Trusted Advisor to get insights, Support Plan adapted to your needs
- Send Service Logs and Access Logs to S3 or CloudWatch Logs
- CloudTrail to record API calls made within your account
- If your Account is compromised: change the root password, delete and rotate all passwords / keys, contact the AWS support

Billing and Costing Tools - Summary

- **Compute Optimizer**: recommends resources' configurations to reduce cost
- **Pricing Calculator**: cost of services on AWS
- **Billing Dashboard**: high level overview + free tier dashboard

- **Cost Allocation Tags**: tag resources to create detailed reports
- **Cost and Usage Reports**: most comprehensive billing dataset
- **Cost Explorer**: View current usage (detailed) and forecast usage
- **Billing Alarms**: in us-east-1 – track overall and per-service billing
- **Budgets**: more advanced – track usage, costs, RI, and get alerts
- **Savings Plans**: easy way to save based on long-term usage of AWS

Advanced Identity

AWS STS (SecurityToken Service)

- Enables you to create **temporary, limited- privileges credentials** to access your AWS resources
- Short-term credentials: you configure expiration period
- Use cases
  - Identity federation: manage user identities in external systems, and provide them with STS tokens to access AWS resources
  - IAM Roles for cross/same account access
  - IAM Roles for Amazon EC2: provide temporary credentials for EC2 instances to access AWS resources

Amazon Cognito (simplified)

- Identity for your Web and Mobile applications users (potentially millions)
- Instead of creating them an IAM user, you create a user in Cognito

What is Microsoft Active Directory (AD)?

- Found on any Windows Server with AD Domain Services
- Database of objects: User Accounts, Computers, Printers, File Shares, Security Groups
- Centralized security management, create account, assign permissions

AWS Directory Services

- **AWS Managed Microsoft AD**
  - Create your own AD in AWS, manage users locally, supports MFA
  - Establish “trust” connections with your on- premise AD
- **AD Connector**
  - Directory Gateway (proxy) to redirect to on- premise AD, supports MFA
  - Users are managed on the on-premise AD

- **Simple AD**
  - AD-compatible managed directory on AWS
  - Cannot be joined with on-premise AD

AWS Single Sign-On (SSO)

- Centrally manage Single SignOn to access multiple accounts and 3rd-party business applications.
- Integrated with AWS Organizations
- Supports SAML 2.0 markup
- Integration with on-premise Active Directory

Summary

- **IAM**
  - Identity and Access Management inside your AWS account
  - For users that you trust and belong to your company
- **Organizations**: manage multiple AWS accounts
- **Security Token Service (STS)**: temporary, limited-privileges credentials to access AWS resources
- **Cognito**: create a database of users for your mobile & web applications
- **Directory Services**: integrate Microsoft Active Directory in AWS
- **Single Sign-On (SSO)**: one login for multiple AWS accounts & applications

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Other AWS Services

- Other AWS Services
  - Amazon WorkSpaces
  - Amazon AppStream 2.0
  - Amazon Sumerian
  - AWS IoT Core
  - Amazon Elastic Transcoder
  - AWS Device Farm
  - AWS Backup
  - AWS Elastic Disaster Recovery (DRS)
  - AWS DataSync
  - AWS Fault Injection Simulator (FIS)

Amazon WorkSpaces

- Managed Desktop as a Service (DaaS) solution to easily provision Windows or Linux desktops
- Great to eliminate management of on-premise VDI (Virtual Desktop Infrastructure)
- Fast and quickly scalable to thousands of users
- Secured data – integrates with KMS
- Pay-as-you-go service with monthly or hourly rates

Amazon AppStream 2.0

- Desktop Application Streaming Service
- Deliver to any computer, without acquiring, provisioning infrastructure
- The application is delivered from within a web browser

Amazon AppStream 2.0	**WorkSpaces**
Stream a desktop application to web browsers (no need to connect to a VDI)	Fully managed VDI and desktop available
Works with any device (that has a web browser)	The users connect to the VDI and open native or WAM applications
Allow to configure an instance type per application type (CPU, RAM, GPU)	Workspaces are on-demand or always on

Amazon Sumerian

- Create and run virtual reality (VR), augmented reality (AR), and 3D applications
- Can be used to quickly create 3D models with animations
- Ready-to-use templates and assets - no programming or 3D expertise required
- Accessible via a web-browser URLs or on popular hardware for AR/VR
- Example: https://docs.aws.amazon.com/sumerian/latest/userguide/gettingstartedshowcase.html

AWS IoT Core

- IoT stands for “Internet of Things” – the network of internet-connected devices that are able to collect and transfer data
- AWS IoT Core allows you to easily connect IoT devices to the AWS Cloud • Serverless, secure & scalable to billions of devices and trillions of messages
- Your applications can communicate with your devices even when they aren’t connected
- Integrates with a lot of AWS services (Lambda, S3, SageMaker, etc.)
- Build IoT applications that gather, process, analyze, and act on data

Amazon Elastic Transcoder

- Elastic Transcoder is used to **convert media files stored in S3 into media files in the formats required by consumer playback devices (phones etc..)**
- Benefits:
    - Easy to use
    - Highly scalable – can handle large volumes of media files and large file sizes
    - Cost effective – duration-based pricing model
    - Fully managed & secure, pay for what you use

AWS Device Farm

- Fully-managed service that tests your web and mobile apps against desktop browsers, real mobile devices, and tablets
- Run tests concurrently on multiple devices (speed up execution)
- Ability to configure device settings (GPS, language, Wi-Fi, Bluetooth, etc.)

AWS Backup

- Fully-managed service to centrally manage and automate backups across AWS services
- On-demand and scheduled backups
- Supports PITR (Point-in-time Recovery)
- Retention Periods, Lifecycle Management, Backup Policies,etc.
- Cross-Region Backup
- Cross-Account Backup (using AWS Organizations)

AWS Elastic Disaster Recovery (DRS)

- Used to be named "CloudEndure Disaster Recovery"
- Quickly and easily **recover** your physical, virtual, and cloud-based servers into AWS
- Example: protect your most critical databases (including Oracle, MySQL, and SQL Server), enterprise apps (SAP), protect your data from ransomware attacks, ...
- Continuous block-level replication for your servers

AWS DataSync

- Move large amount of data from on-premises to AWS
- Can synchronize to: Amazon S3 (any storage classes – including Glacier), Amazon EFS, Amazon FSx for Windows
- Replication tasks can be scheduled hourly, daily, weekly
- The replication tasks are incremental after the first full load

AWS Fault Injection Simulator (FIS)

- A fully managed service for running fault injection experiments on AWS workloads
- Based on **Chaos Engineering** – stressing an application by creating disruptive events (e.g., sudden increase in CPU or memory), observing how the system responds, and implementing improvements
- Helps you uncover hidden bugs and performance bottlenecks
- Supports the following AWS services: EC2, ECS, EKS, RDS...
- Use pre-built templates that generate the desired disruptions

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AWS Architecting and Ecosystem

    - AWS Well-Architected Tool
    - AWS Right Sizing
    - AWS Ecosystem - Free resources
        - AWS Ecosystem - AWS Support
    - AWS Marketplace

Well Architected Framework General Guiding Principles

- Stop guessing your capacity needs
- Test systems at production scale
- Automate to make architectural experimentation easier
- Allow for evolutionary architectures
    - Design based on changing requirements
- Drive architectures using data
- Improve through game days
    - Simulate applications for flash sale days

AWS Cloud Best Practices - Design Principles

- **Scalability**: vertical & horizontal
- **Disposable Resources**: servers should be disposable & easily configured
- **Automation**: Serverless, Infrastructure as a Service, Auto Scaling…
- **Loose Coupling**:
    - Monolith are applications that do more and more over time, become bigger
    - Break it down into smaller, loosely coupled components
    - A change or a failure in one component should not cascade to other components
- **Services, not Servers**:
    - Don’t use just EC2
    - Use managed services, databases, serverless, etc..

Well Architected Framework 6 Pillars

1. Operational Excellence
2. Security
3. Reliability
4. Performance Efficiency
5. Cost Optimization
6. Sustainability

1. Operational Excellence

- Includes the ability to run and monitor systems to deliver business value and to continually improve supporting processes and procedures
- Design Principles
    - **Perform operations as code** - Infrastructure as code
    - **Annotate documentation** - Automate the creation of annotated documentation after every build
    - **Make frequent, small, reversible changes** - So that in case of any failure, you can reverse it

    - **Refine operations procedures frequently** - And ensure that team members are familiar with it
    - **Anticipate failure**
    - **Learn from all operational failures**

2. Security

- Includes the ability to protect information, systems, and assets while delivering business value through risk assessments and mitigation strategies
- Design Principles
    - **Implement a strong identity foundation** - Centralize privilege management and reduce (or even eliminate) reliance on long-term credentials - Principle of least privilege - IAM
    - **Enable traceability** - Integrate logs and metrics with systems to automatically respond and take action
    - **Apply security at all layers** - Like edge network, VPC, subnet, load balancer, every instance, operating system, and application
    - **Automate security best practices**
    - **Protect data in transit and at rest** - Encryption, tokenization, and access control
    - **Keep people away from data** - Reduce or eliminate the need for direct access or manual processing of data
    - **Prepare for security events** - Run incident response simulations and use tools with automation to increase your speed for detection, investigation, and recovery
    - **Shared Responsibility Mode**

3. Reliability

- Ability of a system to recover from infrastructure or service disruptions, dynamically acquire computing resources to meet demand, and mitigate disruptions such as misconfigurations or transient network issues
- Design Principles
    - Test recovery procedures - Use automation to simulate different failures or to recreate scenarios that led to failures before
    - Automatically recover from failure - Anticipate and remediate failures before they occur
    - Scale horizontally to increase aggregate system availability - Distribute requests across multiple, smaller resources to ensure that they don't share a common point of failure
    - Stop guessing capacity - Maintain the optimal level to satisfy demand without over or under provisioning - Use Auto Scaling
    - Manage change in automation - Use automation to make changes to infrastructure

4. Performance Efficiency

- Includes the ability to use computing resources efficiently to meet system requirements, and to maintain that efficiency as demand changes and technologies evolve
- Design Principles
    - **Democratize advanced technologies** - Advance technologies become services and hence you can focus more on product development
    - **Go global in minutes** - Easy deployment in multiple regions
    - **Use serverless architectures** - Avoid burden of managing servers
    - **Experiment more often** - Easy to carry out comparative testing

- **Mechanical sympathy** - Be aware of all AWS services

5. Cost Optimization

- Includes the ability to run systems to deliver business value at the lowest price point
- Design Principles
  - **Adopt a consumption mode** - Pay only for what you use
  - **Measure overall efficiency** - Use CloudWatch
  - **Stop spending money on data center operations** - AWS does the infrastructure part and enables customer to focus on organization projects
  - **Analyze and attribute expenditure** - Accurate identification of system usage and costs, helps measure return on investment (ROI) - Make sure to use tags
  - **Use managed and application level services to reduce cost of ownership** - As managed services operate at cloud scale, they can offer a lower cost per transaction or service

6. Sustainability

- The sustainability pillar focuses on minimizing the environmental impacts of running cloud workloads.
- Design Principles
  - **Understand your impact** – establish performance indicators, evaluate improvements
  - **Establish sustainability goals** – Set long-term goals for each workload, model return on investment (ROI)
  - **Maximize utilization** – Right size each workload to maximize the energy efficiency of the underlying hardware and minimize idle resources.
  - **Anticipate and adopt new, more efficient hardware and software offerings** – and design for flexibility to adopt new technologies over time.
  - **Use managed services** – Shared services reduce the amount of infrastructure; Managed services help automate sustainability best practices as moving infrequent accessed data to cold storage and adjusting compute capacity.
  - **Reduce the downstream impact of your cloud workloads** – Reduce the amount of energy or resources required to use your services and reduce the need for your customers to upgrade their devices

AWS Well-Architected Tool

- Free tool to **review your architectures** against the 6 pillars Well-Architected Framework and **adopt architectural best practices**
- How does it work?
  - Select your workload and answer questions
  - Review your answers against the 6 pillars
  - Obtain advice: get videos and documentations, generate a report, see the results in a dashboard
- Let's have a look: https://console.aws.amazon.com/wellarchitected

AWS Right Sizing

- EC2 has many instance types, but choosing the most powerful instance type isn't the best choice, because the cloud is elastic

- Right sizing is the process of matching instance types and sizes to your workload performance and capacity requirements at the lowest possible cost
- Scaling up is easy so always start small
- It's also the process of looking at deployed instances and identifying opportunities to eliminate or downsize without compromising capacity or other requirements, which results in lower costs
- It's important to Right Size...
    - before a Cloud Migration
    - continuously after the cloud onboarding process (requirements change over time)
- CloudWatch, Cost Explorer, Trusted Advisor, 3rd party tools can help

AWS Ecosystem - Free resources

- AWS Blogs: https://aws.amazon.com/blogs/aws/
- AWS Forums (community): https://forums.aws.amazon.com/index.jspa
- AWS Whitepapers & Guides: https://aws.amazon.com/whitepapers
- AWS Quick Starts: https://aws.amazon.com/quickstart/
    - Automated, gold-standard deployments in the AWS Cloud
    - Build your production environment quickly with templates
    - Example: WordPress on AWS https://fwd.aws/P3yyv?did=qs_card&trk=qs_card
    - Leverages CloudFormation
- AWS Solutions: https://aws.amazon.com/solutions/
    - Vetted Technology Solutions for the AWS Cloud
    - Example - AWS Landing Zone: secure, multi-account AWS environment
        - https://aws.amazon.com/solutions/implementations/aws-landing-zone/
        - "Replaced" by AWS Control Tower

AWS Ecosystem - AWS Support

DEVELOPER	**BUSINESS**	**ENTERPRISE**
Business hours email access to Cloud Support Associates	24x7 phone, email, and chat access to Cloud Support Engineers	Access to a Technical Account Manager (TAM)
General guidance: < 24 business hours	Production system impaired: < 4 hours	Concierge Support Team (for billing and account best practices)
System impaired: < 12 business hours	Production system down: < 1 hour	Business-critical system down: < 15 minutes

AWS Marketplace

- Digital catalog with thousands of software listings from **independent software vendors** (3rd party)
- Example:
    - Custom AMI (custom OS, firewalls, technical solutions...)
    - CloudFormation templates
    - Software as a Service
    - Containers
- If you buy through the AWS Marketplace, it goes into your AWS bill
- You can **sell your own solutions** on the AWS Marketplace

Please feel free to comment below if any information is inaccurate or if any answers need correction.

If this guide has been helpful to you please share it with others and react to this below.

Thank You.