Security Groups
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 authorised by default

EC2 Instances Purchasing Options

- **On-Demand Instances** – short workload, predictable pricing, pay by second
- **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, cheap, can lose instances (less reliable)
- **Dedicated Hosts** – book an entire physical server, control instance placement
- **Dedicated Instances** – no other customers will share your hardware
- **Capacity Reservations** – reserve capacity in a specific AZ for any duration

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

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

EBS Volume Types

- EBS Volumes come in 6 types
  - gp2 / gp3 (SSD): General purpose SSD volume that balances price and performance for a wide variety of workloads
  - io1 / io2 Block Express (SSD): Highest-performance SSD volume for mission-critical low-latency or high-throughput workloads
  - st1 (HDD): Low cost HDD volume designed for frequently accessed, throughput-intensive workloads
  - sc1 (HDD): Lowest cost HDD volume designed for less frequently accessed workloads
- EBS Volumes are characterized in Size | Throughput | IOPS (I/O Ops Per Sec)
- When in doubt always consult the AWS documentation – it's good!
- **Only gp2/gp3 and io1/io2 Block Express can be used as boot volumes**

EBS Encryption

- When you create an encrypted EBS volume, you get the following:
  - Data at rest is encrypted inside the volume
  - All the data in flight moving between the instance and the volume is encrypted
  - All snapshots are encrypted
  - All volumes created from the snapshot
- Encryption and decryption are handled transparently (you have nothing to do)
- Encryption has a minimal impact on latency
- EBS Encryption leverages keys from KMS (AES-256)
- Copying an unencrypted snapshot allows encryption
- Snapshots of encrypted volumes are encrypted

EC2 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

Note: the % discounts are different from the video as AWS change them over time – the exact numbers are not needed for the exam. This is just for illustrative purposes ☺

EBS – Volume Types Summary

	General Purpose SSD volumes		Provisioned IOPS SSD volumes	
Volume type	gp3	gp2	io2 Block Express [3]	io1
Durability	99.8% - 99.9% durability (0.1% - 0.2% annual failure rate)		99.999% durability (0.001% annual failure rate)	99.8% - 99.9% durability (0.1% - 0.2% annual failure rate)
Use cases	• Transactional workloads • Virtual desktops • Medium-sized, single-instance databases • Low-latency interactive applications • Boot volumes • Development and test environments		Workloads that require: • Sub-millisecond latency • Sustained IOPS performance • More than 64,000 IOPS or 1,000 MiB/s of throughput	• Workloads that require sustained IOPS performance or more than 16,000 IOPS • I/O-intensive database workloads
Volume size	1 GiB - 16 TiB		4 GiB - 64 TiB [4]	4 GiB - 16 TiB
Max IOPS per volume (16 KiB I/O)	16,000		256,000 [5]	64,000
Max throughput per volume	1,000 MiB/s	250 MiB/s [1]	4,000 MiB/s	1,000 MiB/s [2]
Amazon EBS Multi-attach	Not supported		Supported	
NVMe reservations	Not supported		Supported	Not supported
Boot volume	Supported			

	Throughput Optimized HDD volumes	Cold HDD volumes
Volume type	st1	sc1
Durability	99.8% - 99.9% durability (0.1% - 0.2% annual failure rate)	
Use cases	• Big data • Data warehouses • Log processing	• Throughput-oriented storage for data that is infrequently accessed • Scenarios where the lowest storage cost is important
Volume size	125 GiB - 16 TiB	
Max IOPS per volume (1 MiB I/O)	500	250
Max throughput per volume	500 MiB/s	250 MiB/s
Amazon EBS Multi-attach	Not supported	
Boot volume	Not supported	

https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/ebs-volume-types.html#solid-state-drives

SSL/TLS - Basics

- An SSL Certificate allows traffic between your clients and your load balancer to be encrypted in transit (in-flight encryption)

- **SSL** refers to Secure Sockets Layer, used to encrypt connections
- **TLS** refers to Transport Layer Security, which is a newer version
- Nowadays, **TLS certificates are mainly used**, but people still refer as SSL

- Public SSL certificates are issued by Certificate Authorities (CA)
- Comodo, Symantec, GoDaddy, GlobalSign, Digicert, Letsencrypt, etc…

- SSL certificates have an expiration date (you set) and must be renewed

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
- BUT you can't SSH into your instances

Types of load balancer on AWS

- AWS has 4 kinds of managed Load Balancers
- **Classic Load Balancer** (v1 - old generation) – 2009 – CLB
  - HTTP, HTTPS, TCP, SSL (secure TCP)
- **Application Load Balancer** (v2 - new generation) – 2016 – ALB
  - HTTP, HTTPS, WebSocket
- **Network Load Balancer** (v2 - new generation) – 2017 – NLB
  - TCP, TLS (secure TCP), UDP
- **Gateway Load Balancer** – 2020 – GWLB
  - Operates at layer 3 (Network layer) – IP Protocol

- Overall, it is recommended to use the newer generation load balancers as they provide more features
- Some load balancers can be setup as internal (private) or external (public) ELBs

Auto Scaling Groups – Scaling Policies

- Dynamic Scaling
  - Target Tracking Scaling
    - Simple to set-up
    - Example: I want the average ASG CPU to stay at around 40%
  - 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
- Scheduled Scaling
  - Anticipate a scaling based on known usage patterns
  - Example: increase the min capacity to 10 at 5 pm on Fridays

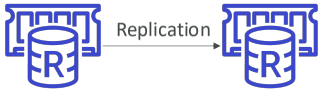
Features of Aurora

- Automatic fail-over
- Backup and Recovery
- Isolation and security
- Industry compliance
- Push-button scaling
- Automated Patching with Zero Downtime
- Advanced Monitoring
- Routine Maintenance
- Backtrack: restore data at any point of time without using backups

ElastiCache – Redis vs Memcached

REDIS

- **Multi AZ** with Auto-Failover
- **Read Replicas** to scale reads and have **high availability**
- Data Durability using AOF persistence
- **Backup and restore features**
- Supports Sets and Sorted Sets



MEMCACHED

- Multi-node for partitioning of data (sharding)
- **No high availability (replication)**
- **Non persistent**
- **No backup and restore**
- Multi-threaded architecture

Amazon Aurora

- Aurora is a proprietary technology from AWS (not open sourced)
- Postgres and MySQL are both supported as Aurora DB (that means your drivers will work as if Aurora was a Postgres or MySQL database)
- 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 128 TB.
- Aurora can have up to 15 replicas and the replication process is faster than MySQL (sub 10 ms replica lag)
- Failover in Aurora is instantaneous. It's HA (High Availability) native.
- Aurora costs more than RDS (20% more) – but is more efficient

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 really high performance, low latency
- Helps reduce load off of databases for read intensive workloads
- Helps make your application stateless
- AWS takes care of OS maintenance / patching, optimizations, setup, configuration, monitoring, failure recovery and backups
- Using ElastiCache involves heavy application code changes

Instantiating Applications quickly

- EC2 Instances:
  - **Use a Golden AMI:** Install your applications, OS dependencies etc.. beforehand and launch your EC2 instance from the Golden AMI
  - **Bootstrap using User Data:** For dynamic configuration, use User Data scripts
  - **Hybrid:** mix Golden AMI and User Data (Elastic Beanstalk)
- RDS Databases:
  - Restore from a snapshot: the database will have schemas and data ready!
- EBS Volumes:
  - Restore from a snapshot: the disk will already be formatted and have data!

Amazon S3 - 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
  - Must NOT start with the prefix **xn--**
  - Must NOT end with the suffix **-s3alias**

S3 Bucket

Route 53 – Routing Policies

- Define how Route 53 responds to DNS queries
- Don't get confused by the word *"Routing"*
  - It's not the same as Load balancer routing which routes the traffic
  - DNS does not route any traffic, it only responds to the DNS queries
- Route 53 Supports the following Routing Policies
  - Simple
  - Weighted
  - Failover
  - Latency based
  - Geolocation
  - Multi-Value Answer
  - Geoproximity (using Route 53 Traffic Flow feature)

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, …
- Managed service
  - Automatically handles capacity provisioning, load balancing, scaling, application health monitoring, instance configuration, …
  - Just the application code is the responsibility of the developer
- We still have full control over the configuration
- Beanstalk is free but you pay for the underlying instances

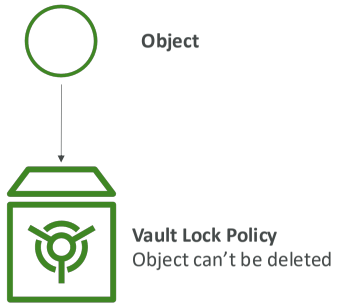
S3 Standard – General Purpose

- 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 Glacier Vault Lock

- Adopt a WORM (Write Once Read Many) model
- Create a Vault Lock Policy
- Lock the policy for future edits (can no longer be changed or deleted)
- Helpful for compliance and data retention



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

Amazon S3 – Object Encryption

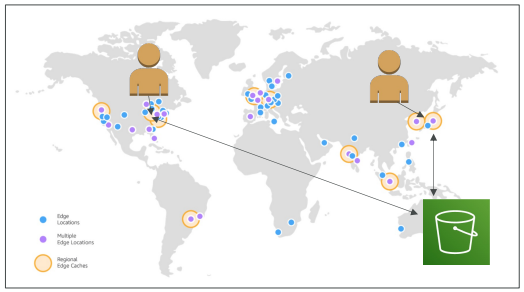
- You can encrypt objects in S3 buckets using one of 4 methods

- Server-Side Encryption (SSE)
  - Server-Side Encryption with Amazon S3-Managed Keys (SSE-S3) – Enabled by Default
    - Encrypts S3 objects using keys handled, managed, and owned by AWS
  - Server-Side Encryption with KMS Keys stored in AWS KMS (SSE-KMS)
    - Leverage AWS Key Management Service (AWS KMS) to manage encryption keys
  - Server-Side Encryption with Customer-Provided Keys (SSE-C)
    - When you want to manage your own encryption keys
- Client-Side Encryption

- It's important to understand which ones are for which situation for the exam

Amazon 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

AWS Global Accelerator

- Works with **Elastic IP, EC2 instances, ALB, NLB, public or private**
- Consistent Performance
  - Intelligent routing to lowest latency and fast regional failover
  - No issue with client cache (because the IP doesn't change)
  - Internal AWS network
- Health Checks
  - Global Accelerator performs a health check of your applications
  - Helps make your application global (failover less than 1 minute for unhealthy)
  - Great for disaster recovery (thanks to the health checks)
- Security
  - only 2 external IP need to be whitelisted
  - DDoS protection thanks to AWS Shield

S3 Object Lock (versioning must be enabled)

- Adopt a WORM (Write Once Read Many) model
- Block an object version deletion for a specified amount of time
- **Retention mode - Compliance**:
  - Object versions can't be overwritten or deleted by any user, including the root user
  - Objects retention modes can't be changed, and retention periods can't be shortened
- **Retention mode - Governance:**
  - Most users can't overwrite or delete an object version or alter its lock settings
  - Some users have special permissions to change the retention or delete the object
- **Retention Period**: protect the object for a fixed period, it can be extended
- **Legal Hold:**
  - protect the object indefinitely, independent from retention period
  - can be freely placed and removed using the *s3:PutObjectLegalHold* IAM permission

CloudFront vs S3 Cross Region Replication

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

AWS Snow Family

- Highly-secure, portable devices to **collect and process data at the edge**, and **migrate data into and out of AWS**

Snowcone

Snowball Edge

	Snowcone	Snowball Edge
Storage Capacity	8 TB HDD - 14 TB SSD	80 TB - 210 TB
Migration Size	Up to terabytes	Up to petabytes

AWS DataSync

- Move large amount of data to and from
  - On-premises / other cloud to AWS (NFS, SMB, HDFS, S3 API…) – **needs agent**
  - AWS to AWS (different storage services) – no agent needed
- Can synchronize to:
  - Amazon S3 (any storage classes – including Glacier)
  - Amazon EFS
  - Amazon FSx (Windows, Lustre, NetApp, OpenZFS...)
- Replication tasks can be scheduled hourly, daily, weekly
- **File permissions and metadata are preserved** (NFS POSIX, SMB…)
- One agent task can use 10 Gbps, can setup a bandwidth limit

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
  - Improves performance for both cacheable content (such as images and videos)
  - Dynamic content (such as API acceleration and dynamic site delivery)
  - Content is served at the edge

- Global Accelerator
  - Improves performance for a wide range of applications over TCP or UDP
  - Proxying packets at the edge to applications running in one or more AWS Regions.
  - Good fit for non-HTTP use cases, such as gaming (UDP), IoT (MQTT), or Voice over IP
  - Good for HTTP use cases that require static IP addresses
  - Good for HTTP use cases that required deterministic, fast regional failover

AWS Storage Gateway

- Bridge between on-premises data and cloud data
- Use cases:
  - disaster recovery
  - backup & restore
  - tiered storage
  - on-premises cache & low-latency files access

Storage Gateway

- Types of Storage Gateway:
  - S3 File Gateway
  - FSx File Gateway
  - Volume Gateway
  - Tape Gateway

Amazon SQS – FIFO Queue

- FIFO = First In First Out (ordering of messages in the queue)

- Limited throughput: 300 msg/s without batching, 3000 msg/s with
- Exactly-once send capability (by removing duplicates)
- Messages are processed in order by the consumer

Kinesis Data Streams

- Retention between 1 day to 365 days
- Ability to reprocess (replay) data
- Once data is inserted in Kinesis, it can't be deleted (immutability)
- Data that shares the same partition goes to the same shard (ordering)
- Producers: AWS SDK, Kinesis Producer Library (KPL), Kinesis Agent
- Consumers:
  - Write your own: Kinesis Client Library (KCL), AWS SDK
  - Managed: AWS Lambda, Kinesis Data Firehose, Kinesis Data Analytics,

Storage Comparison

- **S3:** Object Storage
- **S3 Glacier:** Object Archival
- **EBS volumes:** Network storage for one EC2 instance at a time
- **Instance Storage:** Physical storage for your EC2 instance (high IOPS)
- **EFS:** Network File System for Linux instances, POSIX filesystem
- **FSx for Windows:** Network File System for Windows servers
- **FSx for Lustre:** High Performance Computing Linux file system
- **FSx for NetApp ONTAP:** High OS Compatibility
- **FSx for OpenZFS:** Managed ZFS file system
- **Storage Gateway:** S3 & FSx File Gateway, Volume Gateway (cache & stored), Tape Gateway
- **Transfer Family:** FTP, FTPS, SFTP interface on top of Amazon S3 or Amazon EFS
- **DataSync:** Schedule data sync from on-premises to AWS, or AWS to AWS
- **Snowcone / Snowball / Snowmobile:** to move large amount of data to the cloud, physically
- **Database:** for specific workloads, usually with indexing and querying

Kinesis Overview

- Makes it easy to **collect**, **process**, and **analyze** streaming data in real-time
- Ingest real-time data such as: Application logs, Metrics, Website clickstreams, IoT telemetry data…




- **Kinesis Data Streams:** capture, process, and store data streams
- **Kinesis Data Firehose:** load data streams into AWS data stores
- **Kinesis Data Analytics:** analyze data streams with SQL or Apache Flink
- **Kinesis Video Streams:** capture, process, and store video streams

Kinesis Data Streams vs Firehose

Kinesis Data Streams

- Streaming service for ingest at scale
- Write custom code (producer / consumer)
- Real-time (~200 ms)
- Manage scaling (shard splitting / merging)
- Data storage for 1 to 365 days
- Supports replay capability

Kinesis Data Firehose

- Load streaming data into S3 / Redshift / OpenSearch / 3rd party / custom HTTP
- Fully managed
- Near real-time
- Automatic scaling
- No data storage
- Doesn't support replay capability

Docker Containers Management on AWS

- **Amazon Elastic Container Service (Amazon ECS)**
  - Amazon's own container platform
- **Amazon Elastic Kubernetes Service (Amazon EKS)**
  - Amazon's managed Kubernetes (open source)
- **AWS Fargate**
  - Amazon's own Serverless container platform
  - Works with ECS and with EKS
- **Amazon ECR:**
  - Store container images

Amazon ECS

Amazon EKS

AWS Fargate

Amazon ECR

Kinesis Data Firehose

- Fully Managed Service, no administration, automatic scaling, serverless
  - AWS: Redshift / Amazon S3 / OpenSearch
  - 3rd party partner: Splunk / MongoDB / DataDog / NewRelic / …
  - Custom: send to any HTTP endpoint
- Pay for data going through Firehose
- **Near Real Time**
  - Buffer interval: 0 seconds (no buffering) to 900 seconds
  - Buffer size: minimum 1MB
- Supports many data formats, conversions, transformations, compression
- Supports custom data transformations using AWS Lambda
- Can send failed or all data to a backup S3 bucket

SQS vs SNS vs Kinesis

SQS:

- Consumer "pull data"
- Data is deleted after being consumed
- Can have as many workers (consumers) as we want
- No need to provision throughput
- Ordering guarantees only on FIFO queues
- Individual message delay capability

SNS:

- Push data to many subscribers
- Up to 12,500,000 subscribers
- Data is not persisted (lost if not delivered)
- Pub/Sub
- Up to 100,000 topics
- No need to provision throughput
- Integrates with SQS for fan-out architecture pattern
- FIFO capability for SQS FIFO

Kinesis:

- Standard: pull data
  - 2 MB per shard
- Enhanced-fan out: push data
  - 2 MB per shard per consumer
- Possibility to replay data
- Meant for real-time big data, analytics and ETL
- Ordering at the shard level
- Data expires after X days
- Provisioned mode or on-demand capacity mode

Amazon EKS Overview


- Amazon EKS = Amazon Elastic **Kubernetes** Service
- It is a way to launch **managed Kubernetes clusters on AWS**
- Kubernetes is an **open-source system** for automatic deployment, scaling and management of containerized (usually Docker) application
- It's an alternative to ECS, similar goal but different API
- EKS supports **EC2** if you want to deploy worker nodes or **Fargate** to deploy serverless containers
- **Use case:** if your company is already using Kubernetes on-premises or in another cloud, and wants to migrate to AWS using Kubernetes
- Kubernetes is cloud-agnostic (can be used in any cloud – Azure, GCP…)
- For multiple regions, deploy one EKS cluster per region
- Collect logs and metrics using **CloudWatch Container Insights**

Why AWS Lambda

Amazon EC2

- Virtual Servers in the Cloud
- Limited by RAM and CPU
- Continuously running
- Scaling means intervention to add / remove servers

Amazon Lambda

- Virtual **functions** – no servers to manage!
- Limited by time - **short executions**
- Run **on-demand**
- Scaling is **automated**!

ECS Service Auto Scaling

- Automatically increase/decrease the desired number of ECS tasks

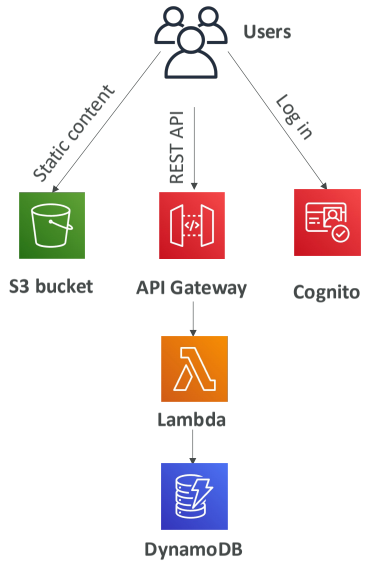
- Amazon ECS Auto Scaling uses **AWS Application Auto Scaling**
  - ECS Service Average CPU Utilization
  - ECS Service Average Memory Utilization - Scale on RAM
  - ALB Request Count Per Target – metric coming from the ALB

- **Target Tracking** – scale based on target value for a specific CloudWatch metric
- **Step Scaling** – scale based on a specified CloudWatch Alarm
- **Scheduled Scaling** – scale based on a specified date/time (predictable changes)

- ECS Service Auto Scaling (task level) ≠ EC2 Auto Scaling (EC2 instance level)
- Fargate Auto Scaling is much easier to setup (because **Serverless**)

Serverless in AWS

- AWS Lambda
- DynamoDB
- AWS Cognito
- AWS API Gateway
- Amazon S3
- AWS SNS & SQS
- AWS Kinesis Data Firehose
- Aurora Serverless
- Step Functions
- Fargate



Amazon DynamoDB

- Fully managed, highly available with replication across multiple AZs
- NoSQL database - not a relational database - with transaction support
- Scales to massive workloads, distributed database
- Millions of requests per seconds, trillions of row, 100s of TB of storage
- Fast and consistent in performance (single-digit millisecond)
- Integrated with IAM for security, authorization and administration
- Low cost and auto-scaling capabilities
- No maintenance or patching, always available
- Standard & Infrequent Access (IA) Table Class

Why CloudFront?

- No changes to architecture
- Will cache software update files at the edge
- Software update files are not dynamic, they're static (never changing)
- Our EC2 instances aren't serverless
- But CloudFront is, and will scale for us
- Our ASG will not scale as much, and we'll save tremendously in EC2
- We'll also save in availability, network bandwidth cost, etc
- Easy way to make an existing application more scalable and cheaper!

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
- 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 API Gateway

- AWS Lambda + API Gateway: No infrastructure to manage
- Support for the WebSocket Protocol
- Handle API versioning (v1, v2…)
- Handle different environments (dev, test, prod…)
- Handle security (Authentication and Authorization)
- Create API keys, handle request throttling
- Swagger / Open API import to quickly define APIs
- Transform and validate requests and responses
- Generate SDK and API specifications
- Cache API responses

Database Types

- **RDBMS (= SQL / OLTP):** RDS, Aurora – great for joins
- **NoSQL database – no joins, no SQL :** DynamoDB (~JSON), ElastiCache (key / value pairs), Neptune (graphs), DocumentDB (for MongoDB), Keyspaces (for Apache Cassandra)
- **Object Store:** S3 (for big objects) / Glacier (for backups / archives)
- **Data Warehouse** (= SQL Analytics / BI): Redshift (OLAP), Athena, EMR
- **Search:** OpenSearch (JSON) – free text, unstructured searches
- **Graphs:** Amazon Neptune – displays relationships between data
- **Ledger**: Amazon Quantum Ledger Database
- **Time series**: Amazon Timestream

- Note: some databases are being discussed in the Data & Analytics section

Amazon Aurora – Summary

- Compatible API for PostgreSQL / MySQL, separation of storage and compute
- Storage: data is stored in 6 replicas, across 3 AZ – highly available, self-healing, auto-scaling
- Compute: Cluster of DB Instance across multiple AZ, auto-scaling of Read Replicas
- Cluster: Custom endpoints for writer and reader DB instances
- Same security / monitoring / maintenance features as RDS
- Know the backup & restore options for Aurora
- **Aurora Serverless –** for unpredictable / intermittent workloads, no capacity planning
- **Aurora Global:** up to 16 DB Read Instances in each region, < 1 second storage replication
- **Aurora Machine Learning:** perform ML using SageMaker & Comprehend on Aurora
- **Aurora Database Cloning:** new cluster from existing one, faster than restoring a snapshot
- **Use case:** same as RDS, but with less maintenance / more flexibility / more performance / more features

Choosing the Right Database

- We have a lot of managed databases on AWS to choose from
- Questions to choose the right database based on your architecture:
  - Read-heavy, write-heavy, or balanced workload? Throughput needs? Will it change, does it need to scale or fluctuate during the day?
  - How much data to store and for how long? Will it grow? Average object size? How are they accessed?
  - Data durability? Source of truth for the data ?
  - Latency requirements? Concurrent users?
  - Data model? How will you query the data? Joins? Structured? Semi-Structured?
  - Strong schema? More flexibility? Reporting? Search? RDBMS / NoSQL?
  - License costs? Switch to Cloud Native DB such as Aurora?

Amazon RDS – Summary

- Managed PostgreSQL / MySQL / Oracle / SQL Server / DB2 / MariaDB / Custom
- Provisioned RDS Instance Size and EBS Volume Type & Size
- Auto-scaling capability for Storage
- Support for Read Replicas and Multi AZ
- Security through IAM, Security Groups, KMS , SSL in transit
- Automated Backup with Point in time restore feature (up to 35 days)
- Manual DB Snapshot for longer-term recovery
- Managed and Scheduled maintenance (with downtime)
- Support for IAM Authentication, integration with Secrets Manager
- RDS Custom for access to and customize the underlying instance (Oracle & SQL Server)

- **Use case:** Store relational datasets (RDBMS / OLTP), perform SQL queries, transactions

Amazon DynamoDB – Summary

- AWS proprietary technology, managed serverless NoSQL database, millisecond latency
- Capacity modes: provisioned capacity with optional auto-scaling or on-demand capacity
- Can replace ElastiCache as a key/value store (storing session data for example, using TTL feature)
- Highly Available, Multi AZ by default, Read and Writes are decoupled, transaction capability
- DAX cluster for read cache, microsecond read latency
- Security, authentication and authorization is done through IAM
- Event Processing: DynamoDB Streams to integrate with AWS Lambda, or Kinesis Data Streams
- Global Table feature: active-active setup
- Automated backups up to 35 days with PITR (restore to new table), or on-demand backups
- Export to S3 without using RCU within the PITR window, import from S3 without using WCU
- **Great to rapidly evolve schemas**

- **Use Case:** Serverless applications development (small documents 100s KB), distributed serverless cache

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
- DocumentDB storage automatically grows in increments of 10GB

- Automatically scales to workloads with millions of requests per seconds

Amazon ElastiCache – Summary

- Managed Redis / Memcached (similar offering as RDS, but for caches)
- In-memory data store, sub-millisecond latency
- Select an ElastiCache instance type (e.g., cache.m6g.large)
- Support for Clustering (Redis) and Multi AZ, Read Replicas (sharding)
- Security through IAM, Security Groups, KMS, Redis Auth
- Backup / Snapshot / Point in time restore feature
- Managed and Scheduled maintenance
- **Requires some application code changes to be leveraged**

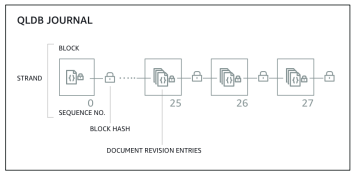
- **Use Case:** Key/Value store, Frequent reads, less writes, cache results for DB queries, store session data for websites, cannot use SQL.

Amazon S3 – Summary

- S3 is a… key / value store for objects
- Great for bigger objects, not so great for many small objects
- Serverless, scales infinitely, max object size is 5 TB, versioning capability
- **Tiers:** S3 Standard, S3 Infrequent Access, S3 Intelligent, S3 Glacier + lifecycle policy
- **Features:** Versioning, Encryption, Replication, MFA-Delete, Access Logs…
- **Security:** IAM, Bucket Policies, ACL, Access Points, Object Lambda, CORS, Object/Vault Lock
- **Encryption:** SSE-S3, SSE-KMS, SSE-C, client-side, TLS in transit, default encryption
- **Batch operations** on objects using S3 Batch, listing files using S3 Inventory
- **Performance:** Multi-part upload, S3 Transfer Acceleration, S3 Select
- **Automation:** S3 Event Notifications (SNS, SQS, Lambda, EventBridge)
- **Use Cases:** static files, key value store for big files, website hosting

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



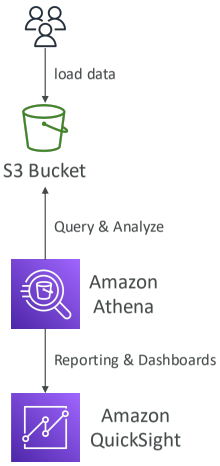
- 2-3x better performance than common ledger blockchain frameworks, manipulate data using SQL
- Difference with Amazon Managed Blockchain: **no decentralization component**, in accordance with financial regulation rules

https://docs.aws.amazon.com/qldb/latest/developerguide/ledger-structure.html

Amazon Athena

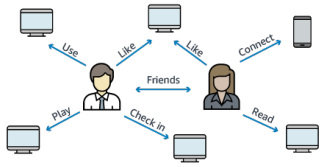
- **Serverless** query service to analyze data stored in Amazon S3
- Uses standard SQL language to query the files (built on Presto)
- Supports CSV, JSON, ORC, Avro, and Parquet
- Pricing: $5.00 per TB of data scanned
- Commonly used with Amazon Quicksight for reporting/dashboards

- **Use cases:** Business intelligence / analytics / reporting, analyze & query VPC Flow Logs, ELB Logs, **CloudTrail trails**, etc...
- **Exam Tip:** analyze data in S3 using serverless SQL, use Athena



Amazon Neptune

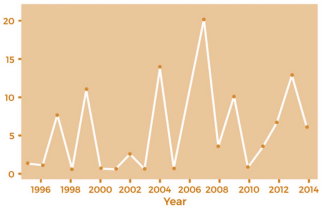
- Fully managed **graph** database
- A popular **graph dataset** would be a **social network**
  - Users have friends
  - Posts have comments
  - Comments have likes from users
  - Users share and like posts…
- Highly available across 3 AZ, with up to 15 read replicas
- Build and run applications working 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 Timestream

- Fully managed, fast, scalable, serverless **time series database**
- Automatically scales up/down to adjust capacity
- Store and analyze trillions of events per day
- 1000s times faster & 1/10th the cost of relational databases
- Scheduled queries, multi-measure records, SQL compatibility
- Data storage tiering: recent data kept in memory and historical data kept in a cost-optimized storage
- Built-in time series analytics functions (helps you identify patterns in your data in near real-time)
- Encryption in transit and at rest

- Use cases: IoT apps, operational applications, real-time analytics, …

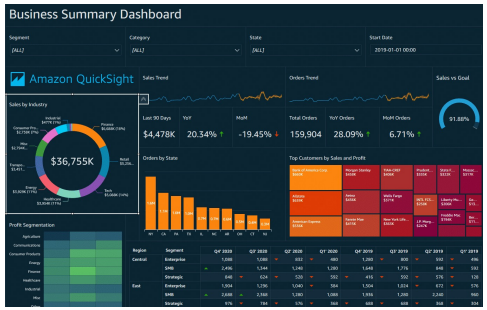


Amazon OpenSearch Service

- *Amazon OpenSearch is successor to Amazon ElasticSearch*
- In DynamoDB, queries only exist by primary key or indexes…
- **With OpenSearch, you can search any field, even partially matches**
- It's common to use OpenSearch as a complement to another database
- Two modes: managed cluster or serverless cluster
- Does *not* natively support SQL (can be enabled via a plugin)
- Ingestion from Kinesis Data Firehose, AWS IoT, and CloudWatch Logs
- Security through Cognito & IAM, KMS encryption, TLS
- Comes with OpenSearch Dashboards (visualization)

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…
- **In-memory computation using SPICE** engine if data is imported into QuickSight
- Enterprise edition: Possibility to setup **Column-Level security (CLS)**



https://aws.amazon.com/quicksight/

Redshift Overview

- Redshift is based on PostgreSQL, but **it's not used for OLTP**
- **It's OLAP – online analytical processing (analytics and data warehousing)**
- 10x better performance than other data warehouses, scale to PBs of data
- **Columnar** storage of data (instead of row based) & parallel query engine
- Two modes: Provisioned cluster or Serverless cluster
- Has a SQL interface for performing the queries
- BI tools such as Amazon Quicksight or Tableau integrate with it
- **vs Athena:** faster queries / joins / aggregations thanks to indexes

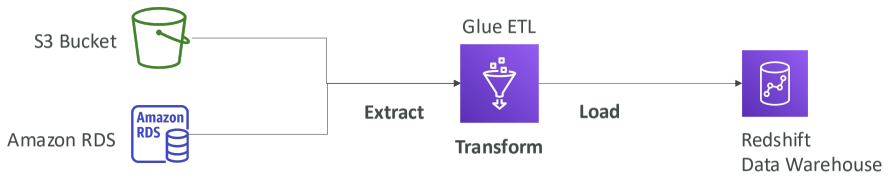
Amazon EMR

- 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**
- EMR comes bundled with 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…**

AWS Glue

- Managed **extract, transform, and load (ETL)** service
- Useful to prepare and transform data for analytics
- Fully **serverless** service



AWS Lake Formation

- **Data lake = central place to have all your data for analytics purposes**
- Fully managed service that makes it easy to setup a **data lake** in days
- Discover, cleanse, transform, and ingest data into your Data Lake
- It automates many complex manual steps (collecting, cleansing, moving, cataloging data, …) and de-duplicate (using ML Transforms)
- Combine structured and unstructured data in the data lake
- **Out-of-the-box source blueprints:** S3, RDS, Relational & NoSQL DB…
- **Fine-grained Access Control for your applications (row and column-level)**
- Built on top of AWS Glue

QuickSight – Dashboard & Analysis

- Define Users (standard versions) and Groups (enterprise version)
  - These users & groups only exist within QuickSight, not IAM !!
- A *dashboard*…
  - is a read-only snapshot of an analysis that you can share
  - preserves the configuration of the analysis (filtering, parameters, controls, sort)

- **You can share the analysis or the dashboard with Users or Groups**
- To share a dashboard, you must first publish it
- Users who see the dashboard can also see the underlying data

Glue – things to know at a high-level

- **Glue Job Bookmarks:** prevent re-processing old data
- **Glue Elastic Views**:
  - Combine and replicate data across multiple data stores using SQL
  - No custom code, Glue monitors for changes in the source data, serverless
  - Leverages a "virtual table" (materialized view)
- **Glue DataBrew:** clean and normalize data using pre-built transformation
- **Glue Studio:** new GUI to create, run and monitor ETL jobs in Glue
- **Glue Streaming ETL** (built on Apache Spark Structured Streaming): compatible with Kinesis Data Streaming, Kafka, MSK (managed Kafka)

Amazon Managed Streaming for Apache Kafka (Amazon MSK)

- Alternative to Amazon Kinesis
- Fully managed Apache Kafka on AWS
  - Allow you to create, update, delete clusters
  - MSK creates & manages Kafka brokers nodes & Zookeeper nodes for you
  - Deploy the MSK cluster in your VPC, multi-AZ (up to 3 for HA)
  - Automatic recovery from common Apache Kafka failures
  - Data is stored on EBS volumes **for as long as you want**
- **MSK Serverless**
  - Run Apache Kafka on MSK without managing the capacity
  - MSK automatically provisions resources and scales compute & storage

Amazon Comprehend Medical

- Amazon Comprehend Medical detects and returns useful information in unstructured clinical text:
  - Physician's notes
  - Discharge summaries
  - Test results
  - Case notes
- **Uses NLP to detect Protected Health Information (PHI)** – *DetectPHI* API
- Store your documents in Amazon S3, analyze real-time data with Kinesis Data Firehose, or use Amazon Transcribe to transcribe patient narratives into text that can be analyzed by Amazon Comprehend Medical.

Kinesis Data Analytics (SQL application)

- Real-time analytics on **Kinesis Data Streams & Firehose** using SQL
- Add reference data from Amazon S3 to enrich streaming data
- Fully managed, no servers to provision
- Automatic scaling
- Pay for actual consumption rate
- Output:
  - Kinesis Data Streams: create streams out of the real-time analytics queries
  - Kinesis Data Firehose: send analytics query results to destinations
- Use cases:
  - Time-series analytics
  - Real-time dashboards
  - Real-time metrics

Kinesis Data Streams vs. Amazon MSK

Kinesis Data Streams

- 1 MB message size limit
- Data Streams with Shards
- Shard Splitting & Merging
- TLS In-flight encryption
- KMS at-rest encryption

Amazon MSK

- 1MB default, configure for higher (ex: 10MB)
- Kafka Topics with Partitions
- Can only add partitions to a topic
- PLAINTEXT or TLS In-flight Encryption
- KMS at-rest encryption

Amazon CloudWatch Metrics

- CloudWatch provides metrics for *every* services in AWS
- **Metric** is a variable to monitor (CPUUtilization, NetworkIn…)
- Metrics belong to **namespaces**
- **Dimension** is an attribute of a metric (instance id, environment, etc…).
- Up to 30 dimensions per metric
- Metrics have **timestamps**
- Can create CloudWatch dashboards of metrics
- Can create **CloudWatch Custom Metrics** (for the RAM for example)

CloudWatch Logs Agent & Unified Agent

- For virtual servers (EC2 instances, on-premises servers…)
- **CloudWatch Logs Agent**
  - Old version of the agent
  - Can only send to CloudWatch Logs
- **CloudWatch Unified Agent**
  - Collect additional system-level metrics such as RAM, processes, etc…
  - Collect logs to send to CloudWatch Logs
  - Centralized configuration using SSM Parameter Store

AWS Machine Learning - Summary

- **Rekognition:** face detection, labeling, celebrity recognition
- **Transcribe:** audio to text (ex: subtitles)
- **Polly:** text to audio
- **Translate:** translations
- **Lex:** build conversational bots – chatbots
- **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

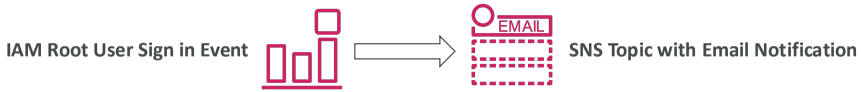
CloudWatch Logs

- **Log groups:** arbitrary name, usually representing an application
- **Log stream:** instances within application / log files / containers
- Can define log expiration policies (never expire, 1 day to 10 years…)
- **CloudWatch Logs can send logs to:**
  - Amazon S3 (exports)
  - Kinesis Data Streams
  - Kinesis Data Firehose
  - AWS Lambda
  - OpenSearch
- Logs are encrypted by default
- Can setup KMS-based encryption with your own keys

Amazon EventBridge (formerly CloudWatch Events)

- Schedule: Cron jobs (scheduled scripts)

- Event Pattern: Event rules to react to a service doing something



- Trigger Lambda functions, send SQS/SNS messages…

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!

CloudWatch Alarms

- Alarms are used to trigger notifications for any metric
- Various options (sampling, %, max, min, etc…)
- Alarm States:
  - OK
  - INSUFFICIENT_DATA
  - ALARM
- Period:
  - Length of time in seconds to evaluate the metric
  - High resolution custom metrics: 10 sec, 30 sec or multiples of 60 sec

CloudWatch Insights and Operational Visibility

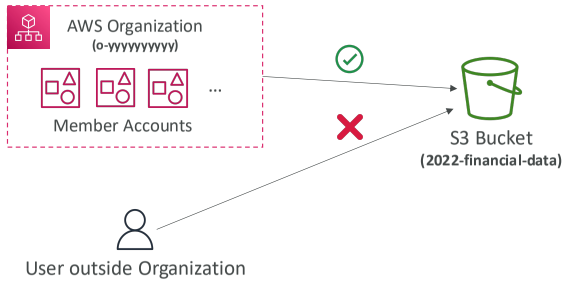
- CloudWatch Container Insights
  - ECS, EKS, Kubernetes on EC2, Fargate, needs agent for Kubernetes
  - Metrics and logs
- CloudWatch Lambda Insights
  - Detailed metrics to troubleshoot serverless applications
- CloudWatch Contributors Insights
  - Find "Top-N" Contributors through CloudWatch Logs
- CloudWatch Application Insights
  - Automatic dashboard to troubleshoot your application and related AWS services

CloudWatch vs CloudTrail vs Config

- CloudWatch
  - Performance monitoring (metrics, CPU, network, etc…) & dashboards
  - Events & Alerting
  - Log Aggregation & Analysis
- CloudTrail
  - Record API calls made within your Account by everyone
  - Can define trails for specific resources
  - Global Service
- Config
  - Record configuration changes
  - Evaluate resources against compliance rules
  - Get timeline of changes and compliance

Resource Policies & aws:PrincipalOrgID

- **aws:PrincipalOrgID** can be used in any resource policies to restrict access to accounts that are member of an AWS Organization




```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Allow",
            "Action": ["s3:PutObject", "s3:GetObject"],
            "Resource": "arn:aws:s3:::2022-financial-data/*",
            "Condition": {
                "StringEquals": {
                    "aws:PrincipalOrgID": ["o-yyyyyyyyyy"]
                }
            }
        }
    ]
}
```


AWS Config

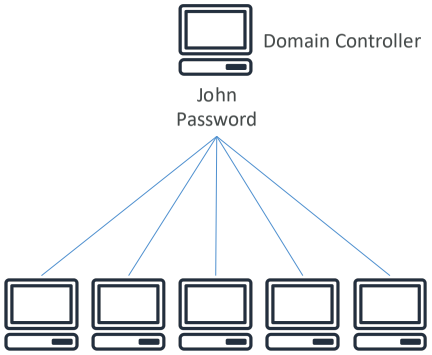
- Helps with auditing and recording **compliance** of your AWS resources
- Helps record configurations and changes over time
- Questions that can be solved by AWS Config:
  - Is there unrestricted SSH access to my security groups?
  - Do my buckets have any public access?
  - How has my ALB configuration 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
- Possibility of storing the configuration data into S3 (analyzed by Athena)

AWS Organizations

- Global service
- Allows to manage multiple AWS accounts
- The main account is the management account
- Other accounts are member accounts
- Member accounts can only be part of one organization
- Consolidated Billing across all accounts - single payment method
- Pricing benefits from aggregated usage (volume discount for EC2, S3…)
- **Shared reserved instances and Savings Plans discounts across accounts**
- API is available to automate AWS account creation

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
- Objects are organized in **trees**
- A group of trees is a **forest**



Why encryption?
Encryption in flight (TLS / SSL)

- Data is encrypted before sending and decrypted after receiving
- TLS certificates help with encryption (HTTPS)
- Encryption in flight ensures no MITM (man in the middle attack) can happen

AWS IAM Identity Center (successor to AWS Single Sign-On)

- One login (single sign-on) for all your
  - **AWS accounts in AWS Organizations**
  - Business cloud applications (e.g., Salesforce, Box, Microsoft 365, …)
  - SAML2.0-enabled applications
  - EC2 Windows Instances
- Identity providers
  - Built-in identity store in IAM Identity Center
  - 3rd party: Active Directory (AD), OneLogin, Okta…

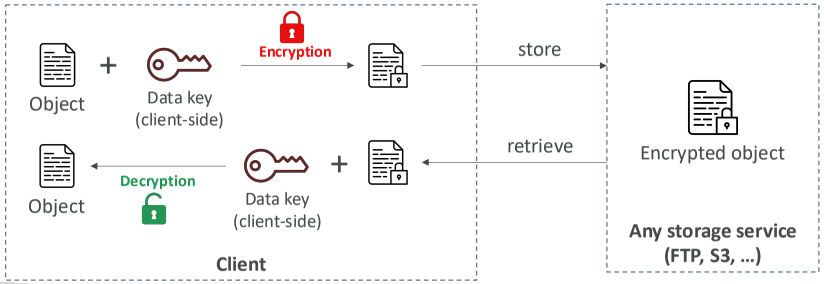
AWS Control Tower

- Easy way to **set up and govern a secure and compliant multi-account AWS environment** based on best practices
- AWS Control Tower uses AWS Organizations to create accounts

- 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

Why encryption?
Client-side encryption

- Data is encrypted by the client and never decrypted by the server
- Data will be decrypted by a receiving client
- The server should not be able to decrypt the data
- Could leverage Envelope Encryption

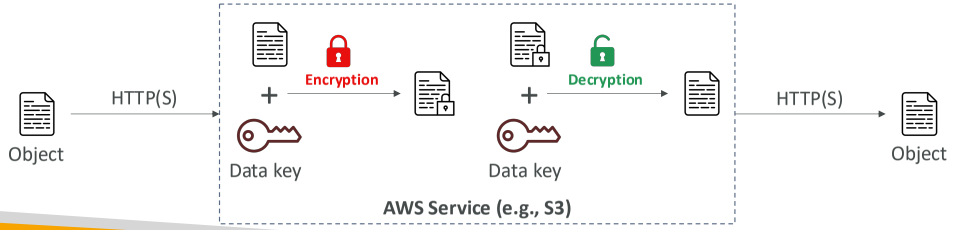


KMS Keys Types

- KMS Keys is the new name of KMS Customer *Master* Key
- Symmetric (AES-256 keys)
  - Single encryption key that is used to Encrypt and Decrypt
  - AWS services that are integrated with KMS use Symmetric CMKs
  - You never get access to the KMS Key unencrypted (must call KMS API to use)
- Asymmetric (RSA & ECC key pairs)
  - Public (Encrypt) and Private Key (Decrypt) pair
  - Used for Encrypt/Decrypt, or Sign/Verify operations
  - The public key is downloadable, but you can't access the Private Key unencrypted
  - Use case: encryption outside of AWS by users who can't call the KMS API

Why encryption?
Server-side encryption at rest

- Data is encrypted after being received by the server
- Data is decrypted before being sent
- It is stored in an encrypted form thanks to a key (usually a data key)
- The encryption / decryption keys must be managed somewhere, and the server must have access to it



AWS KMS (Key Management Service)

- Anytime you hear "encryption" for an AWS service, it's most likely KMS
- AWS manages encryption keys for us
- Fully integrated with IAM for authorization
- Easy way to control access to your data
- Able to audit KMS Key usage using CloudTrail
- Seamlessly integrated into most AWS services (EBS, S3, RDS, SSM…)
- Never ever store your secrets in plaintext, especially in your code!
  - KMS Key Encryption also available through API calls (SDK, CLI)
  - Encrypted secrets can be stored in the code / environment variables

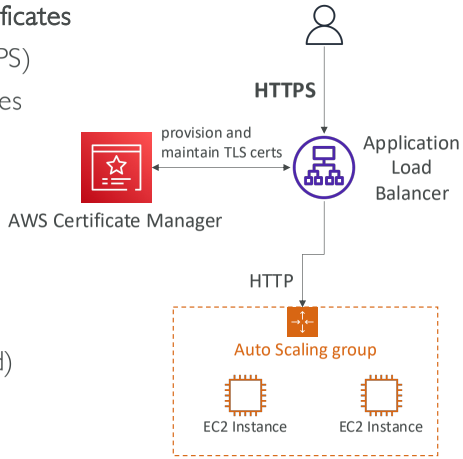
AWS Secrets Manager

- 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

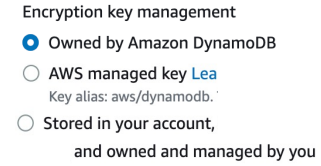
AWS Certificate Manager (ACM)

- Easily provision, manage, and deploy **TLS Certificates**
- 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 (CLB, ALB, NLB)
  - CloudFront Distributions
  - APIs on API Gateway
- Cannot use ACM with EC2 (can't be extracted)



AWS KMS (Key Management Service)

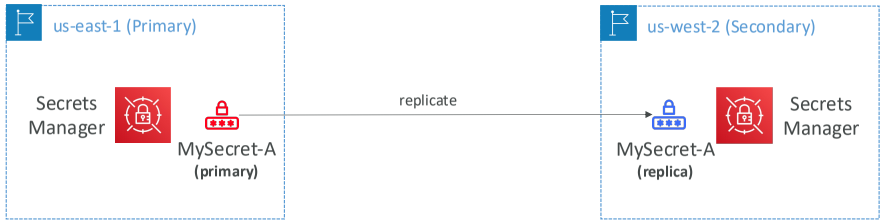
- Types of KMS Keys:
  - AWS Owned Keys (free): SSE-S3, SSE-SQS, SSE-DDB (default key)
  - AWS Managed Key: **free** (aws/*service-name*, example: aws/rds or aws/ebs)
  - Customer managed keys created in KMS: **$1 / month**
  - Customer managed keys imported: **$1 / month**
  - + pay for API call to KMS ($0.03 / 10000 calls)



- Automatic Key rotation:
  - AWS-managed KMS Key: automatic every 1 year
  - Customer-managed KMS Key: (must be enabled) automatic & on-demand
  - Imported KMS Key: only manual rotation possible using alias

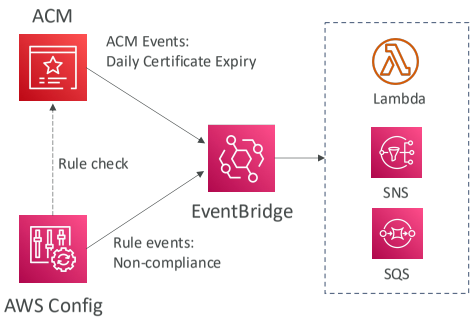
AWS Secrets Manager – Multi-Region Secrets

- Replicate Secrets across multiple AWS Regions
- Secrets Manager keeps read replicas in sync with the primary Secret
- Ability to promote a read replica Secret to a standalone Secret
- Use cases: multi-region apps, disaster recovery strategies, multi-region DB…



ACM – Importing Public Certificates

- Option to generate the certificate outside of ACM and then import it
- **No automatic renewal**, must import a new certificate before expiry
- **ACM sends daily expiration events** starting 45 days prior to expiration
  - The # of days can be configured
  - Events are appearing in EventBridge
- **AWS Config** has a managed rule named *acm-certificate-expiration-check* to check for expiring certificates (configurable number of days)



AWS WAF – Web Application Firewall

- Define Web ACL (Web Access Control List) Rules:
  - **IP Set: up to 10,000 IP addresses** – use multiple Rules for more IPs
  - 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**
- Web ACL are Regional except for CloudFront
- A rule group is **a reusable set of rules that you can add to a web ACL**

ACM – Requesting Public Certificates

1. List domain names to be included in the certificate
   - Fully Qualified Domain Name (FQDN): corp.example.com
   - Wildcard Domain: *.example.com
2. Select Validation Method: DNS Validation or Email validation
   - DNS Validation is preferred for automation purposes
   - Email validation will send emails to contact addresses in the WHOIS database
   - DNS Validation will leverage a CNAME record to DNS config (ex: Route 53)
3. It will take a few hours to get verified
4. The Public Certificate will be enrolled for automatic renewal
   - ACM automatically renews ACM-generated certificates 60 days before expiry

AWS WAF – Web Application Firewall

- Protects your web applications from common web exploits (Layer 7)
- **Layer 7 is HTTP** (vs Layer 4 is TCP/UDP)
- Deploy on
  - Application Load Balancer
  - API Gateway
  - CloudFront
  - AppSync GraphQL API
  - Cognito User Pool

AWS Firewall Manager

- **Manage rules in all accounts of an AWS Organization**
- Security policy: common set of security rules
  - WAF rules (Application Load Balancer, API Gateways, CloudFront)
  - AWS Shield Advanced (ALB, CLB, NLB, Elastic IP, CloudFront)
  - Security Groups for EC2, Application Load BAlancer and ENI resources in VPC
  - AWS Network Firewall (VPC Level)
  - Amazon Route 53 Resolver DNS Firewall
  - Policies are created at the region level
- **Rules are applied to new resources as they are created (good for compliance) across all and future accounts in your Organization**

Amazon GuardDuty

- Intelligent Threat discovery to protect your 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
  - **Optional Features** – EKS Audit Logs, RDS & Aurora, EBS, Lambda, S3 Data Events…
- Can setup **EventBridge rules** to be notified in case of findings
- EventBridge rules can target AWS Lambda or SNS
- **Can protect against CryptoCurrency attacks (has a dedicated "finding" for it)**

AWS Shield: protect from DDoS attack

- **DDoS:** Distributed Denial of Service – many requests at the same time
- **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
  - Shield Advanced automatic application layer DDoS mitigation automatically creates, evaluates and deploys AWS WAF rules to mitigate layer 7 attacks

WAF vs. Firewall Manager vs. Shield

AWS WAF

AWS Firewall Manager

AWS Shield

- **WAF, Shield and Firewall Manager are used together for comprehensive protection**
- Define your Web ACL rules in WAF
- For granular protection of your resources, WAF alone is the correct choice
- If you want to use AWS WAF across accounts, accelerate WAF configuration, automate the protection of new resources, use Firewall Manager with AWS WAF
- Shield Advanced adds additional features on top of AWS WAF, such as dedicated support from the Shield Response Team (SRT) and advanced reporting.
- If you're prone to frequent DDoS attacks, consider purchasing Shield Advanced

AWS 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)**

Internet Gateway (IGW)

- Allows resources (e.g., EC2 instances) in a VPC connect to the Internet
- It scales horizontally and is highly available and redundant
- Must be created separately from a VPC
- One VPC can only be attached to one IGW and vice versa

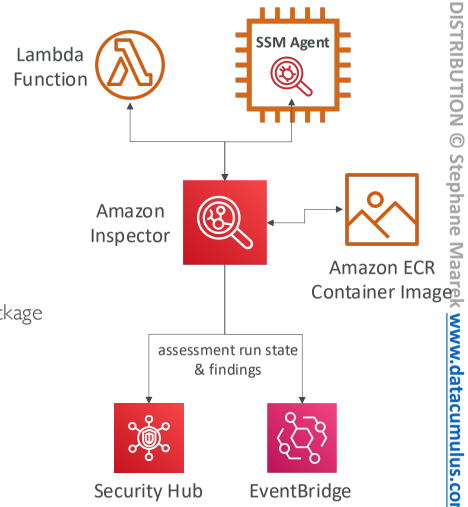
- Internet Gateways on their own do not allow Internet access…
- Route tables must also be edited!

Amazon Inspector

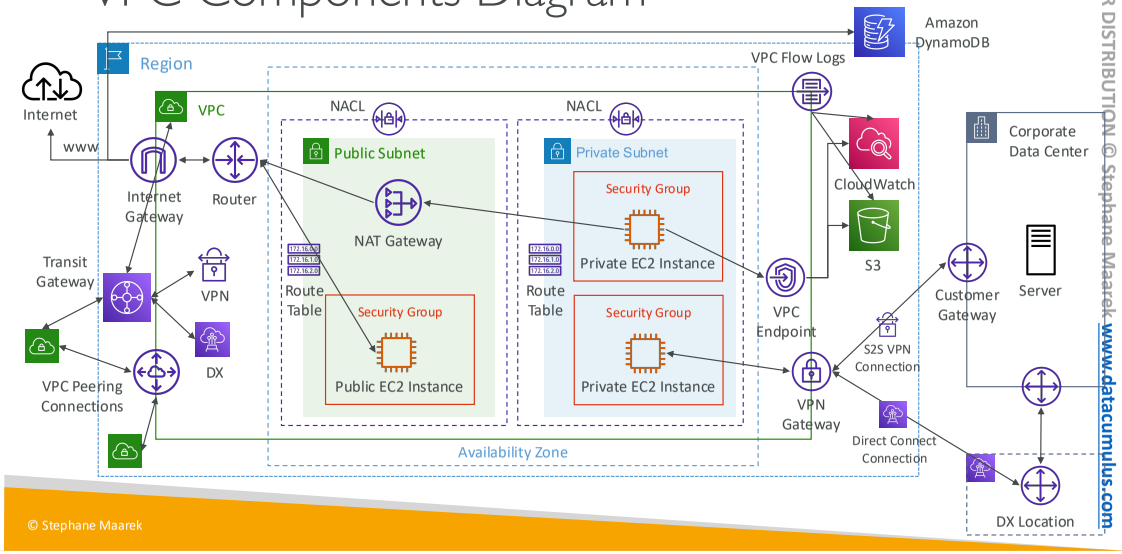
- **Automated Security Assessments**

- For EC2 instances
  - Leveraging the **AWS System Manager (SSM) agent**
  - Analyze against **unintended network accessibility**
  - Analyze the **running OS** against **known vulnerabilities**
- For Container Images push to Amazon ECR
  - Assessment of Container Images as they are pushed
- For Lambda Functions
  - Identifies software vulnerabilities in function code and package dependencies
  - Assessment of functions as they are deployed

- Reporting & integration with AWS Security Hub
- Send findings to Amazon Event Bridge

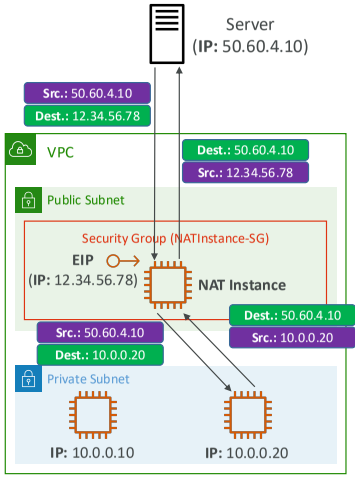


VPC Components Diagram



NAT Instance (**outdated**, but still at the exam)

- NAT = Network Address Translation
- Allows EC2 instances in private subnets to connect to the Internet
- Must be launched in a public subnet
- Must disable EC2 setting: **Source / destination Check**
- Must have Elastic IP attached to it
- Route Tables must be configured to route traffic from private subnets to the NAT Instance

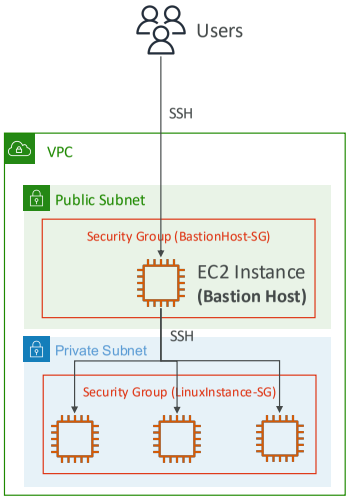


NAT Gateway

- AWS-managed NAT, higher bandwidth, high availability, no administration
- Pay per hour for usage and bandwidth
- NATGW is created in a specific Availability Zone, uses an Elastic IP
- Can't be used by EC2 instance in the same subnet (only from other subnets)
- Requires an IGW (Private Subnet => NATGW => IGW)
- 5 Gbps of bandwidth with automatic scaling up to 100 Gbps
- No Security Groups to manage / required

Bastion Hosts

- We can use a Bastion Host to SSH into our private EC2 instances
- The bastion is in the public subnet which is then connected to all other private subnets
- **Bastion Host security group must allow** inbound from the internet on port 22 from restricted CIDR, for example the public CIDR of your corporation
- **Security Group of the EC2 Instances** must allow the Security Group of the Bastion Host, or the private IP of the Bastion host



NAT Instance – Comments

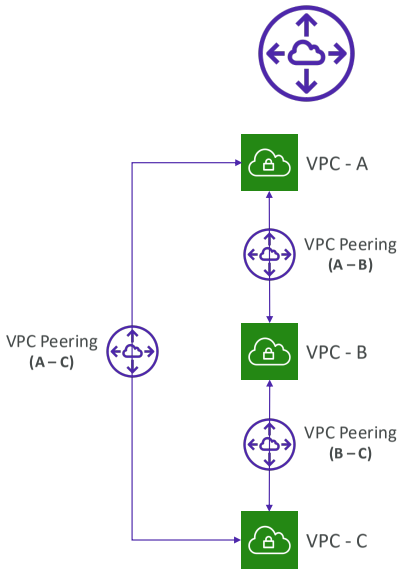
- Pre-configured Amazon Linux AMI is available
  - Reached the end of standard support on December 31, 2020
- Not highly available / resilient setup out of the box
  - You need to create an ASG in multi-AZ + resilient user-data script
- Internet traffic bandwidth depends on EC2 instance type
- You must manage Security Groups & rules:
  - Inbound:
    - Allow HTTP / HTTPS traffic coming from Private Subnets
    - Allow SSH from your home network (access is provided through Internet Gateway)
  - Outbound:
    - Allow HTTP / HTTPS traffic to the Internet

Network Access Control List (NACL)

- NACL are like a firewall which control traffic from and to **subnets**
- **One NACL per subnet,** new subnets are assigned the **Default NACL**
- You define **NACL Rules:**
  - Rules have a number (1-32766), higher precedence with a lower number
  - First rule match will drive the decision
  - Example: if you define #100 ALLOW 10.0.0.10/32 and #200 DENY 10.0.0.10/32, the IP address will be allowed because 100 has a higher precedence over 200
  - The last rule is an asterisk (*) and denies a request in case of no rule match
  - AWS recommends adding rules by increment of 100
- Newly created NACLs will deny everything
- NACL are a great way of blocking a specific IP address at the subnet level

VPC Peering

- Privately connect two VPCs using AWS' network
- Make them behave as if they were in the same network
- Must not have overlapping CIDRs
- VPC Peering connection is **NOT transitive** (must be established for each VPC that need to communicate with one another)
- You must update route tables in each VPC's subnets to ensure EC2 instances can communicate with each other



NAT Gateway vs. NAT Instance

	NAT Gateway	NAT Instance
Availability	Highly available within AZ (create in another AZ)	Use a script to manage failover between instances
Bandwidth	Up to 100 Gbps	Depends on EC2 instance type
Maintenance	Managed by AWS	Managed by you (e.g., software, OS patches, …)
Cost	Per hour & amount of data transferred	Per hour, EC2 instance type and size, + network $
Public IPv4	✓	✓
Private IPv4	✓	✓
Security Groups	✗	✓
Use as Bastion Host?	✗	✓

More at: https://docs.aws.amazon.com/vpc/latest/userguide/vpc-nat-comparison.html

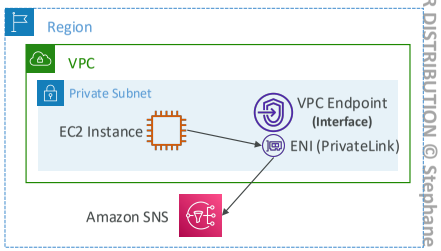
Security Group vs. NACLs

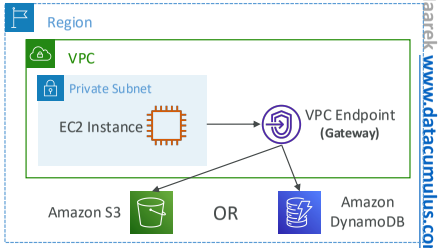
Security Group	NACL
Operates at the instance level	Operates at the subnet level
Supports allow rules only	Supports allow rules and deny rules
Stateful: return traffic is automatically allowed, regardless of any rules	**Stateless:** return traffic must be explicitly allowed by rules (think of ephemeral ports)
All rules are evaluated before deciding whether to allow traffic	Rules are evaluated in order (lowest to highest) when deciding whether to allow traffic, first match wins
Applies to an EC2 instance when specified by someone	Automatically applies to all EC2 instances in the subnet that it's associated with

NACL Examples: https://docs.aws.amazon.com/vpc/latest/userguide/vpc-network-acls.html

Types of Endpoints

- Interface Endpoints (powered by PrivateLink)
  - Provisions an ENI (private IP address) as an entry point (must attach a Security Group)
  - Supports most AWS services
  - $ per hour + $ per GB of data processed
- Gateway Endpoints
  - Provisions a gateway and must be used as a target in a route table (does not use security groups)
  - Supports both S3 and DynamoDB
  - Free



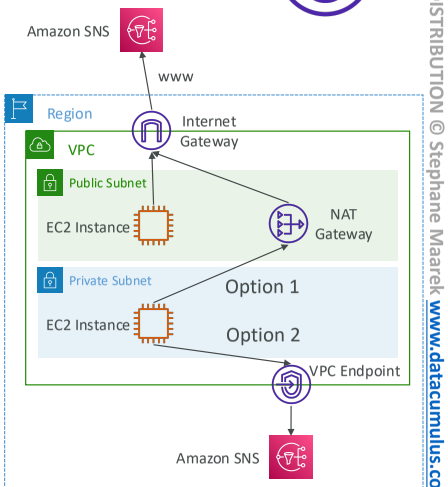


VPC Flow Logs

- Capture information about IP traffic going into your interfaces:
  - VPC Flow Logs
  - Subnet Flow Logs
  - Elastic Network Interface (ENI) Flow Logs
- Helps to monitor & troubleshoot connectivity issues
- Flow logs data can go to S3, CloudWatch Logs, and Kinesis Data Firehose
- Captures network information from AWS managed interfaces too: ELB, RDS, ElastiCache, Redshift, WorkSpaces, NATGW, Transit Gateway…

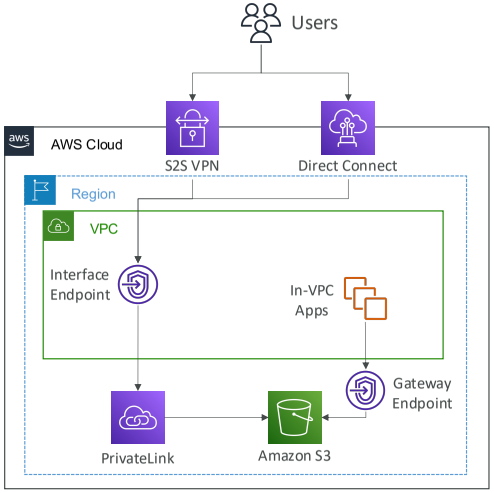
VPC Endpoints (AWS PrivateLink)

- Every AWS service is publicly exposed (public URL)
- VPC Endpoints (powered by AWS PrivateLink) allows you to connect to AWS services using a **private network** instead of using the public Internet
- They're redundant and scale horizontally
- They remove the need of IGW, NATGW, … to access AWS Services
- In case of issues:
  - Check DNS Setting Resolution in your VPC
  - Check Route Tables



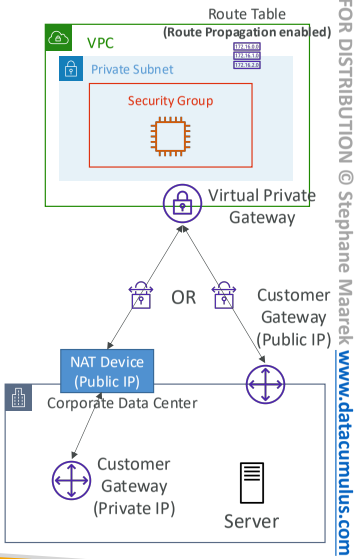
Gateway or Interface Endpoint for S3?

- **Gateway is most likely going to be preferred all the time at the exam**
- Cost: free for Gateway, $ for interface endpoint
- Interface Endpoint is preferred access is required from on-premises (Site to Site VPN or Direct Connect), a different VPC or a different region



Site-to-Site VPN Connections

- Customer Gateway Device (On-premises)
  - What IP address to use?
    - Public Internet-routable IP address for your Customer Gateway device
    - If it's behind a NAT device that's enabled for NAT traversal (NAT-T), use the public IP address of the NAT device
- Important step: enable Route Propagation for the Virtual Private Gateway in the route table that is associated with your subnets
- If you need to ping your EC2 instances from on-premises, make sure you add the ICMP protocol on the inbound of your security groups



Direct Connect (DX)

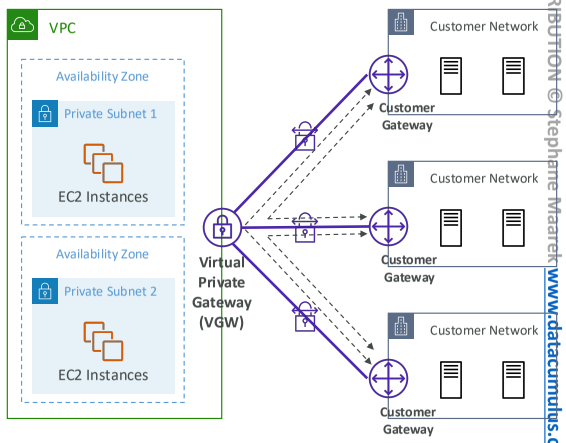
- Provides a dedicated private connection from a remote network to your VPC
- Dedicated connection must be setup between your DC and AWS Direct Connect locations
- You need to setup a Virtual Private Gateway on your VPC
- Access public resources (S3) and private (EC2) on same connection
- Use Cases:
  - Increase bandwidth throughput - working with large data sets – lower cost
  - More consistent network experience - applications using real-time data feeds
  - Hybrid Environments (on prem + cloud)
- Supports both IPv4 and IPv6

AWS Site-to-Site VPN

- Virtual Private Gateway (VGW)
  - VPN concentrator on the AWS side of the VPN connection
  - VGW is created and attached to the VPC from which you want to create the Site-to-Site VPN connection
  - Possibility to customize the ASN (Autonomous System Number)
- Customer Gateway (CGW)
  - Software application or physical device on customer side of the VPN connection
  - https://docs.aws.amazon.com/vpn/latest/s2svpn/your-cgw.html#DevicesTested

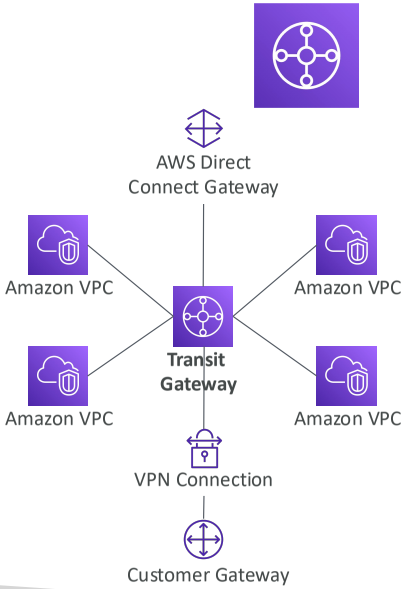
AWS VPN CloudHub

- Provide secure communication between multiple sites, if you have multiple VPN connections
- Low-cost hub-and-spoke model for primary or secondary network connectivity between different locations (VPN only)
- It's a VPN connection so it goes over the public Internet
- To set it up, connect multiple VPN connections on the same VGW, setup dynamic routing and configure route tables



Transit Gateway

- For having transitive peering between thousands of VPC and on-premises, hub-and-spoke (star) connection
- Regional resource, can work cross-region
- Share cross-account using Resource Access Manager (RAM)
- You can peer Transit Gateways across regions
- Route Tables: limit which VPC can talk with other VPC
- Works with Direct Connect Gateway, VPN connections
- Supports **IP Multicast** (not supported by any other AWS service)

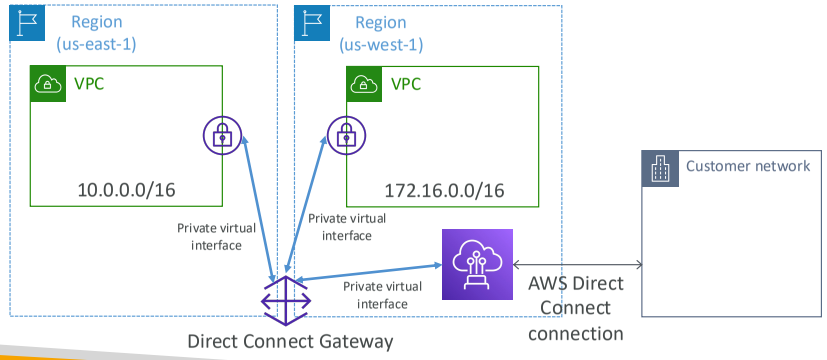


VPC Section Summary (2/3)

- **NACL** – stateless, subnet rules for inbound and outbound, don't forget Ephemeral Ports
- **Security Groups** – stateful, operate at the EC2 instance level
- **VPC Peering** – connect two VPCs with non overlapping CIDR, non-transitive
- **VPC Endpoints** – provide private access to AWS Services (S3, DynamoDB, CloudFormation, SSM) within a VPC
- **VPC Flow Logs** – can be setup at the VPC / Subnet / ENI Level, for ACCEPT and REJECT traffic, helps identifying attacks, analyze using Athena or CloudWatch Logs Insights
- **Site-to-Site VPN** – setup a Customer Gateway on DC, a Virtual Private Gateway on VPC, and site-to-site VPN over public Internet
- **AWS VPN CloudHub** – hub-and-spoke VPN model to connect your sites

Direct Connect Gateway

- If you want to setup a Direct Connect to one or more VPC in many different regions (same account), you must use a Direct Connect Gateway

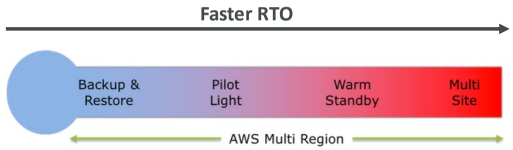


VPC Section Summary (1/3)

- **CIDR** – IP Range
- **VPC** – Virtual Private Cloud => we define a list of IPv4 & IPv6 CIDR
- **Subnets** – tied to an AZ, we define a CIDR
- **Internet Gateway** – at the VPC level, provide IPv4 & IPv6 Internet Access
- **Route Tables** – must be edited to add routes from subnets to the IGW, VPC Peering Connections, VPC Endpoints, …
- **Bastion Host** – public EC2 instance to SSH into, that has SSH connectivity to EC2 instances in private subnets
- **NAT Instances** – gives Internet access to EC2 instances in private subnets. Old, must be setup in a public subnet, disable Source / Destination check flag
- **NAT Gateway** – managed by AWS, provides scalable Internet access to private EC2 instances, when the target is an IPv4 address

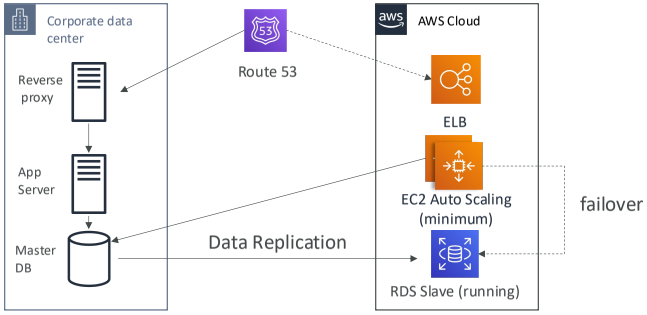
Disaster Recovery Strategies

- Backup and Restore
- Pilot Light
- Warm Standby
- Hot Site / Multi Site Approach



Warm Standby

- Full system is up and running, but at minimum size
- Upon disaster, we can scale to production load

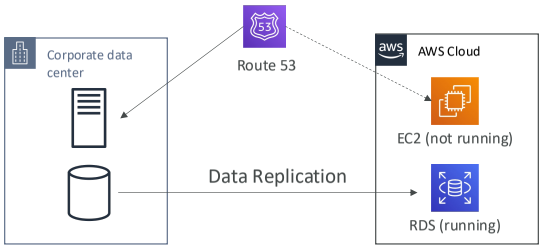


VPC Section Summary (3/3)

- **Direct Connect** – setup a Virtual Private Gateway on VPC, and establish a direct private connection to an AWS Direct Connect Location
- **Direct Connect Gateway** – setup a Direct Connect to many VPCs in different AWS regions
- **AWS PrivateLink / VPC Endpoint Services:**
  - Connect services privately from your service VPC to customers VPC
  - Doesn't need VPC Peering, public Internet, NAT Gateway, Route Tables
  - Must be used with Network Load Balancer & ENI
- **ClassicLink** – connect EC2-Classic EC2 instances privately to your VPC
- **Transit Gateway** – transitive peering connections for VPC, VPN & DX
- **Traffic Mirroring** – copy network traffic from ENIs for further analysis
- **Egress-only Internet Gateway** – like a NAT Gateway, but for IPv6 targets

Disaster Recovery – Pilot Light

- A small version of the app is always running in the cloud
- Useful for the critical core (pilot light)
- Very similar to Backup and Restore
- Faster than Backup and Restore as critical systems are already up



Disaster Recovery Tips

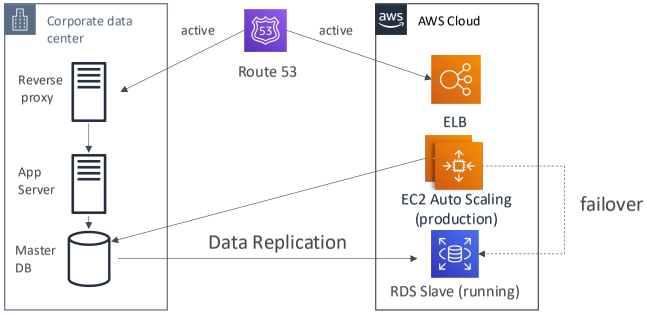
- **Backup**
  - EBS Snapshots, RDS automated backups / Snapshots, etc…
  - Regular pushes to S3 / S3 IA / Glacier, Lifecycle Policy, Cross Region Replication
  - From On-Premise: Snowball or Storage Gateway
- **High Availability**
  - Use Route53 to migrate DNS over from Region to Region
  - RDS Multi-AZ, ElastiCache Multi-AZ, EFS, S3
  - Site to Site VPN as a recovery from Direct Connect
- **Replication**
  - RDS Replication (Cross Region), AWS Aurora + Global Databases
  - Database replication from on-premises to RDS
  - Storage Gateway
- **Automation**
  - CloudFormation / Elastic Beanstalk to re-create a whole new environment
  - Recover / Reboot EC2 instances with CloudWatch if alarms fail
  - AWS Lambda functions for customized automations
- **Chaos**
  - Netflix has a "simian-army" randomly terminating EC2

AWS Backup

- Fully managed service
- Centrally manage and automate backups across AWS services
- No need to create custom scripts and manual processes
- Supported services:
  - Amazon EC2 / Amazon EBS
  - Amazon S3
  - Amazon RDS (all DBs engines) / Amazon Aurora / Amazon DynamoDB
  - Amazon DocumentDB / Amazon Neptune
  - Amazon EFS / Amazon FSx (Lustre & Windows File Server)
  - AWS Storage Gateway (Volume Gateway)
- Supports cross-region backups
- Supports cross-account backups

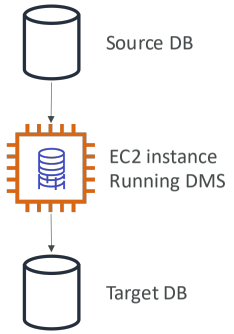
Multi Site / Hot Site Approach

- Very low RTO (minutes or seconds) – very expensive
- Full Production Scale is running AWS and On Premise



DMS – Database Migration Service

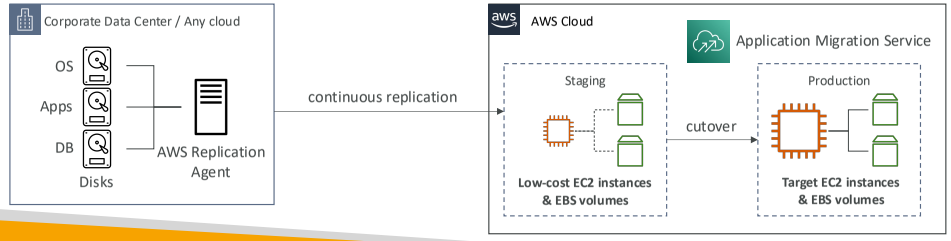
- Quickly and securely migrate databases to AWS, resilient, self healing
- The source database remains available during the migration
- Supports:
  - Homogeneous migrations: ex Oracle to Oracle
  - Heterogeneous migrations: ex Microsoft SQL Server to Aurora
- Continuous Data Replication using CDC
- You must create an EC2 instance to perform the replication tasks



AWS Application Migration Service (MGN)

- *The "AWS evolution" of CloudEndure Migration, replacing AWS Server Migration Service (SMS)*

- Lift-and-shift (rehost) solution which simplify migrating applications to AWS
- Converts your physical, virtual, and cloud-based servers to run natively on AWS
- Supports wide range of platforms, Operating Systems, and databases
- Minimal downtime, reduced costs

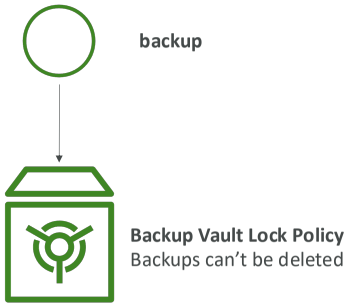


Data Management & Transfer

- AWS Direct Connect:
  - Move GB/s of data to the cloud, over a private secure network
- Snowball & Snowmobile
  - Move PB of data to the cloud
- AWS DataSync
  - Move large amount of data between on-premises and S3, EFS, FSx for Windows

AWS Backup Vault Lock

- Enforce a WORM (Write Once Read Many) state for all the backups that you store in your AWS Backup Vault
- Additional layer of defense to protect your backups against:
  - Inadvertent or malicious delete operations
  - Updates that shorten or alter retention periods
- Even the root user cannot delete backups when enabled



Transferring large amount of data into AWS

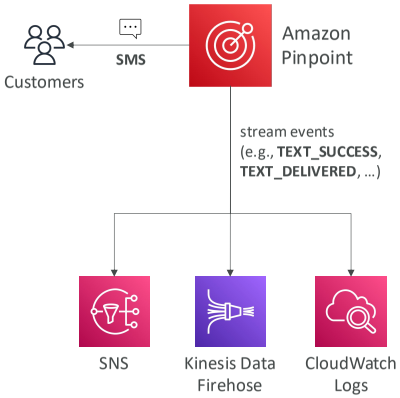
- Example: transfer 200 TB of data in the cloud. We have a 100 Mbps internet connection.
- Over the internet / Site-to-Site VPN:
  - Immediate to setup
  - Will take 200(TB)*1000(GB)*1000(MB)*8(Mb)/100 Mbps = 16,000,000s = 185d
- Over direct connect 1Gbps:
  - Long for the one-time setup (over a month)
  - Will take 200(TB)*1000(GB)*8(Gb)/1 Gbps = 1,600,000s = 18.5d
- Over Snowball:
  - Will take 2 to 3 snowballs in parallel
  - Takes about 1 week for the end-to-end transfer
  - Can be combined with DMS
- For on-going replication / transfers: Site-to-Site VPN or DX with DMS or DataSync

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

Amazon Pinpoint

- Scalable **2-way (outbound/inbound)** marketing communications service
- Supports email, SMS, push, voice, and in-app messaging
- Ability to segment and personalize messages with the right content to customers
- Possibility to receive replies
- Scales to billions of messages per day
- Use cases: run campaigns by sending marketing, bulk, transactional SMS messages
- **Versus Amazon SNS or Amazon SES**
  - In SNS & SES you managed each message's audience, content, and delivery schedule
  - In Amazon Pinpoint, you create message templates, delivery schedules, highly-targeted segments, and full campaigns



Storage

- Instance-attached storage:
  - **EBS:** scale up to 256,000 IOPS with io2 Block Express
  - **Instance Store:** scale to millions of IOPS, linked to EC2 instance, low latency
- Network storage:
  - **Amazon S3:** large blob, not a file system
  - **Amazon EFS:** scale IOPS based on total size, or use provisioned IOPS
  - **Amazon FSx for Lustre:**
    - HPC optimized distributed file system, millions of IOPS
    - Backed by S3

Amazon Simple Email Service (Amazon SES)

- **Fully managed service to send emails securely, globally and at scale**
- Allows inbound/outbound emails
- Reputation dashboard, performance insights, anti-spam feedback
- Provides statistics such as email deliveries, bounces, feedback loop results, email open
- Supports DomainKeys Identified Mail (DKIM) and Sender Policy Framework (SPF)
- Flexible IP deployment: shared, dedicated, and customer-owned IPs
- Send emails using your application using AWS Console, APIs, or SMTP
- Use cases: transactional, marketing and bulk email communications

Cost Explorer

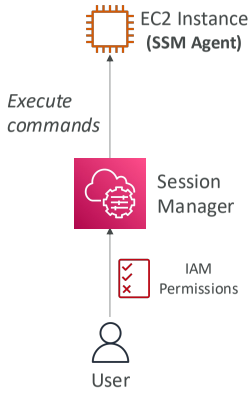
- Visualize, understand, and manage your AWS costs and usage over time
- Create custom reports that analyze cost and usage data.
- Analyze your data at a high level: total costs and usage across all accounts
- Or Monthly, hourly, resource level granularity
- Choose an optimal **Savings Plan** (to lower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

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

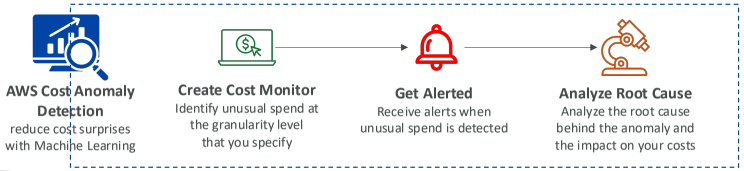
Systems Manager – SSM Session Manager

- 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



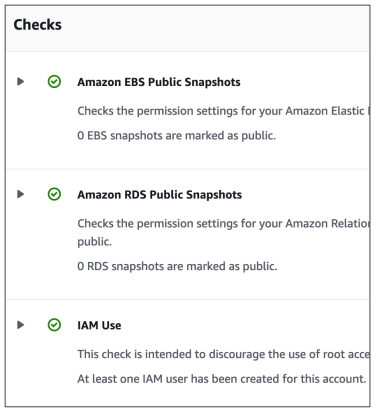
AWS Cost Anomaly Detection

- **Continuously monitor your cost and usage using ML to detect unusual spends**
- It learns your unique, historic spend patterns to detect one-time cost spike and/or continuous cost increases (you don't need to define thresholds)
- Monitor AWS services, member accounts, cost allocation tags, or cost categories
- Sends you the anomaly detection report with root-cause analysis
- Get notified with individual alerts or daily/weekly summary (using SNS)



Trusted Advisor

- No need to install anything – high level AWS account assessment
- Analyze your AWS accounts and provides recommendation on 6 categories:
  - Cost optimization
  - Performance
  - Security
  - Fault tolerance
  - Service limits
  - Operational Excellence
- Business & Enterprise Support plan
  - Full Set of Checks
  - Programmatic Access using AWS Support API



Batch vs Lambda

- Lambda:
  - Time limit
  - Limited runtimes
  - Limited temporary disk space
  - Serverless

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