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EDUCATION

AWS Solutions Architect

S3, rest storage services

Н. Ганжигүүр
Fibo Cloud

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Typical Archictecture

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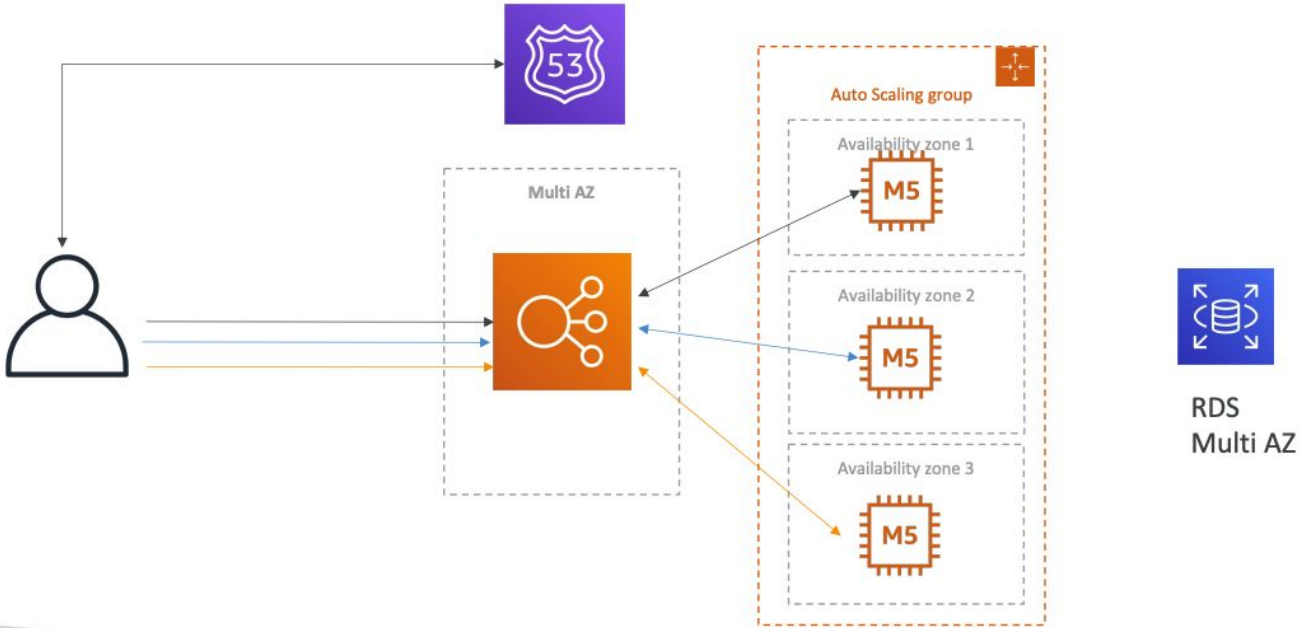
Stateful Web App: MyWordPress.com

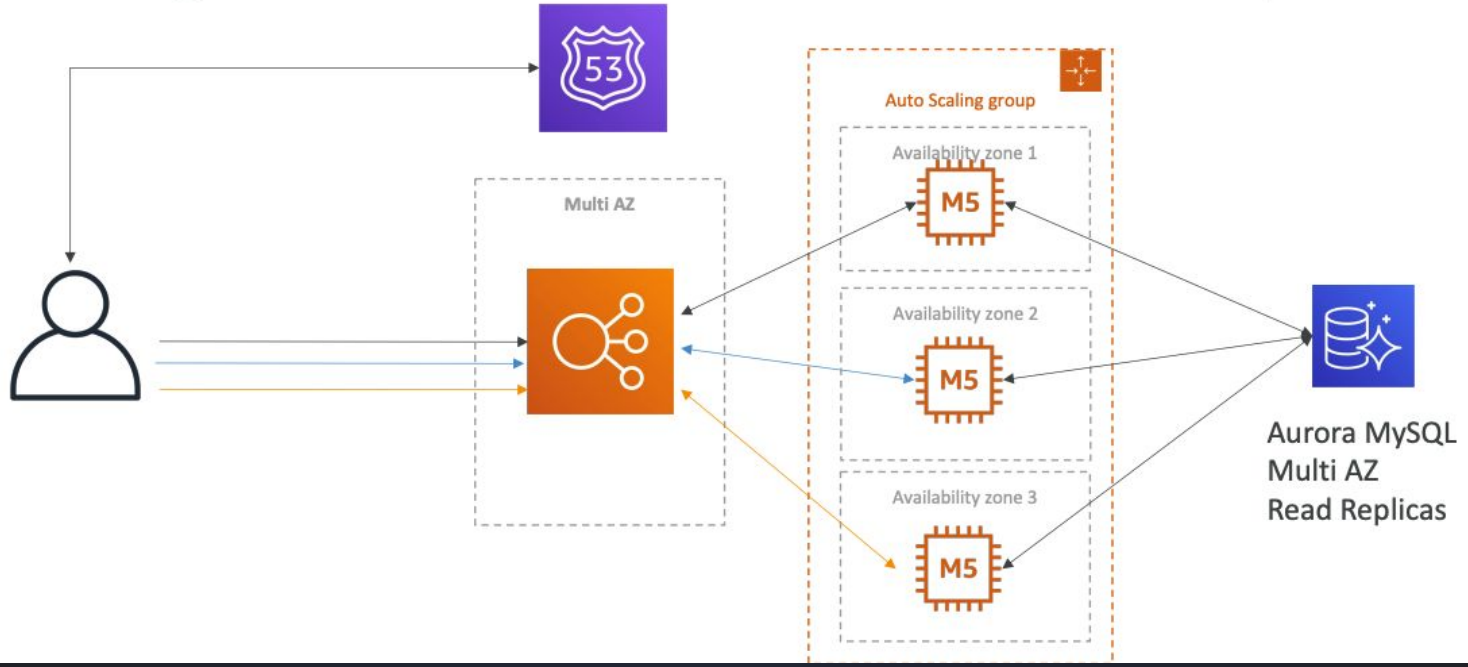
- We are trying to create a fully scalable WordPress website
- We want that website to access and correctly display picture uploads
- Our user data, and the blog content should be stored in a MySQL database.

- Let's see how we can achieve this!

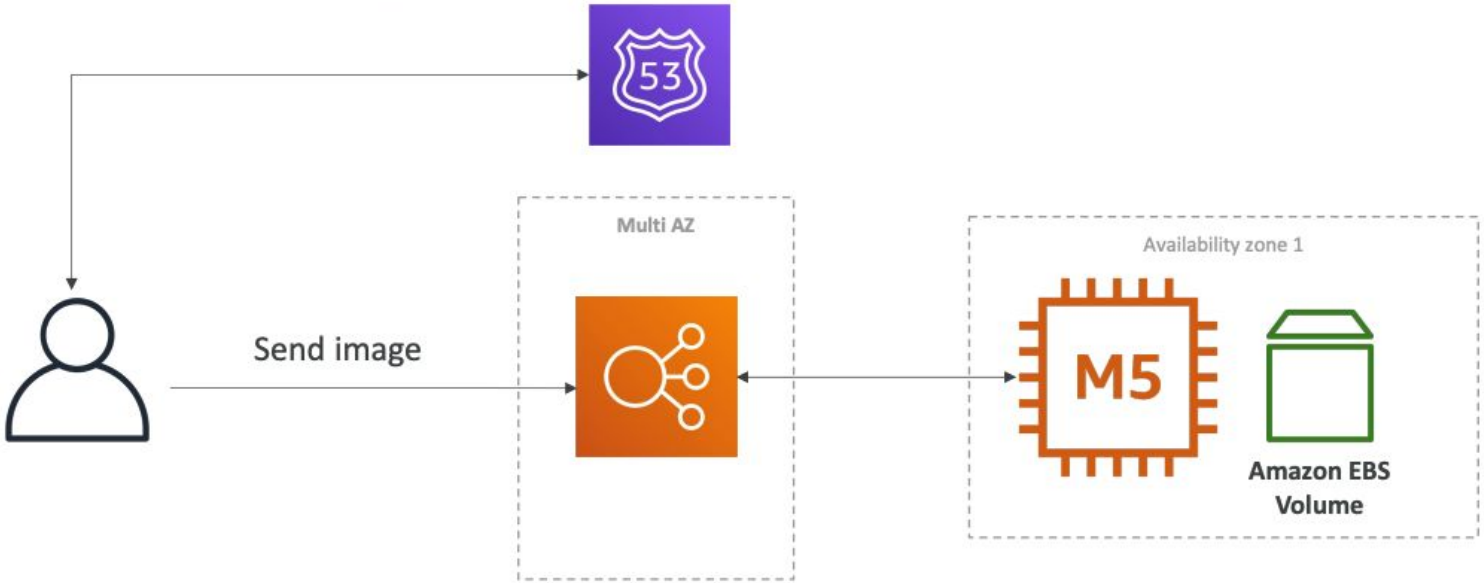
Stateful Web App: MyWordPress.com
RDS layer



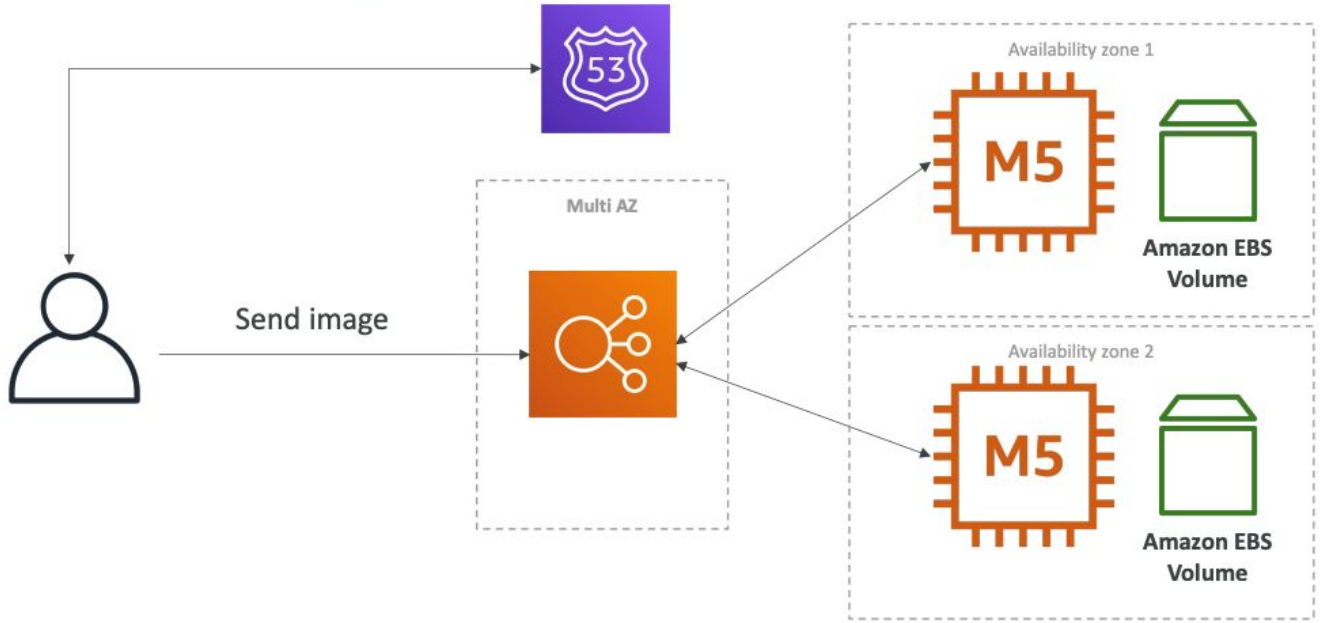
Stateful Web App: MyWordPress.com
Scaling with Aurora: Multi AZ & Read Replicas



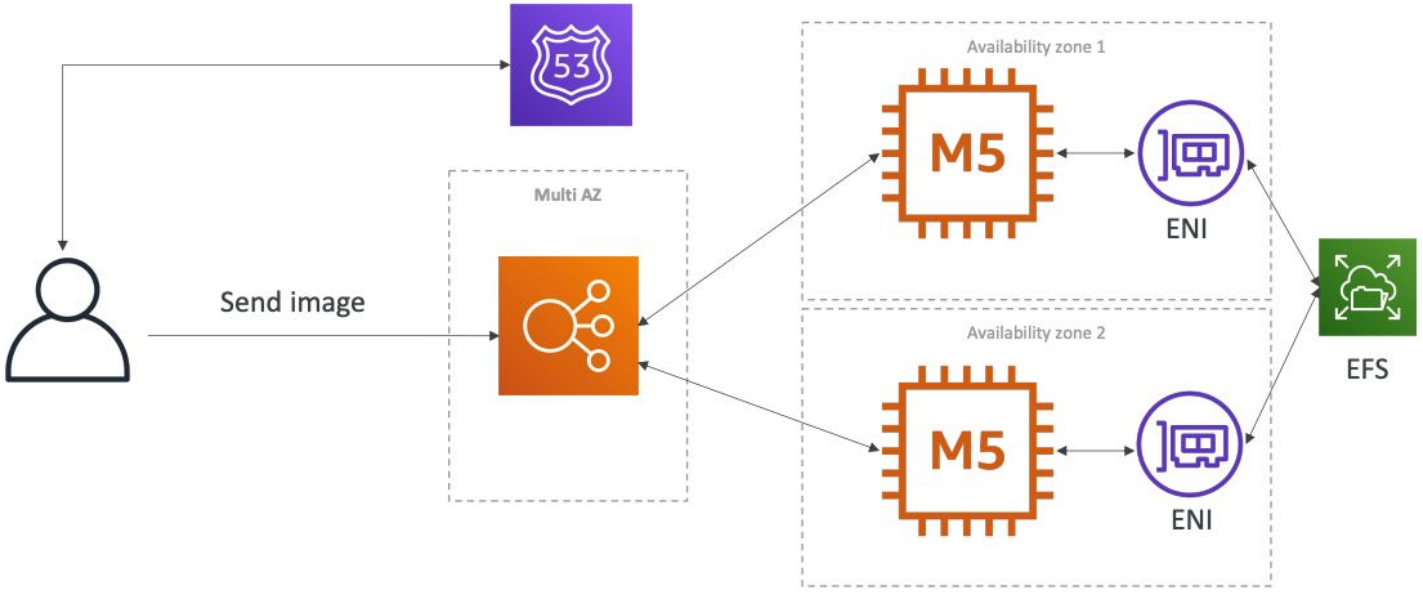
Stateful Web App: MyWordPress.com
Storing images with EBS



Stateful Web App: MyWordPress.com
Storing images with EBS



Stateful Web App: MyWordPress.com
Storing images with EFS



Instantiating Applications quickly

- When launching a full stack (EC2, EBS, RDS), it can take time to:
  - Install applications
  - Insert initial (or recovery) data
  - Configure everything
  - Launch the application
- We can take advantage of the cloud to speed that up!

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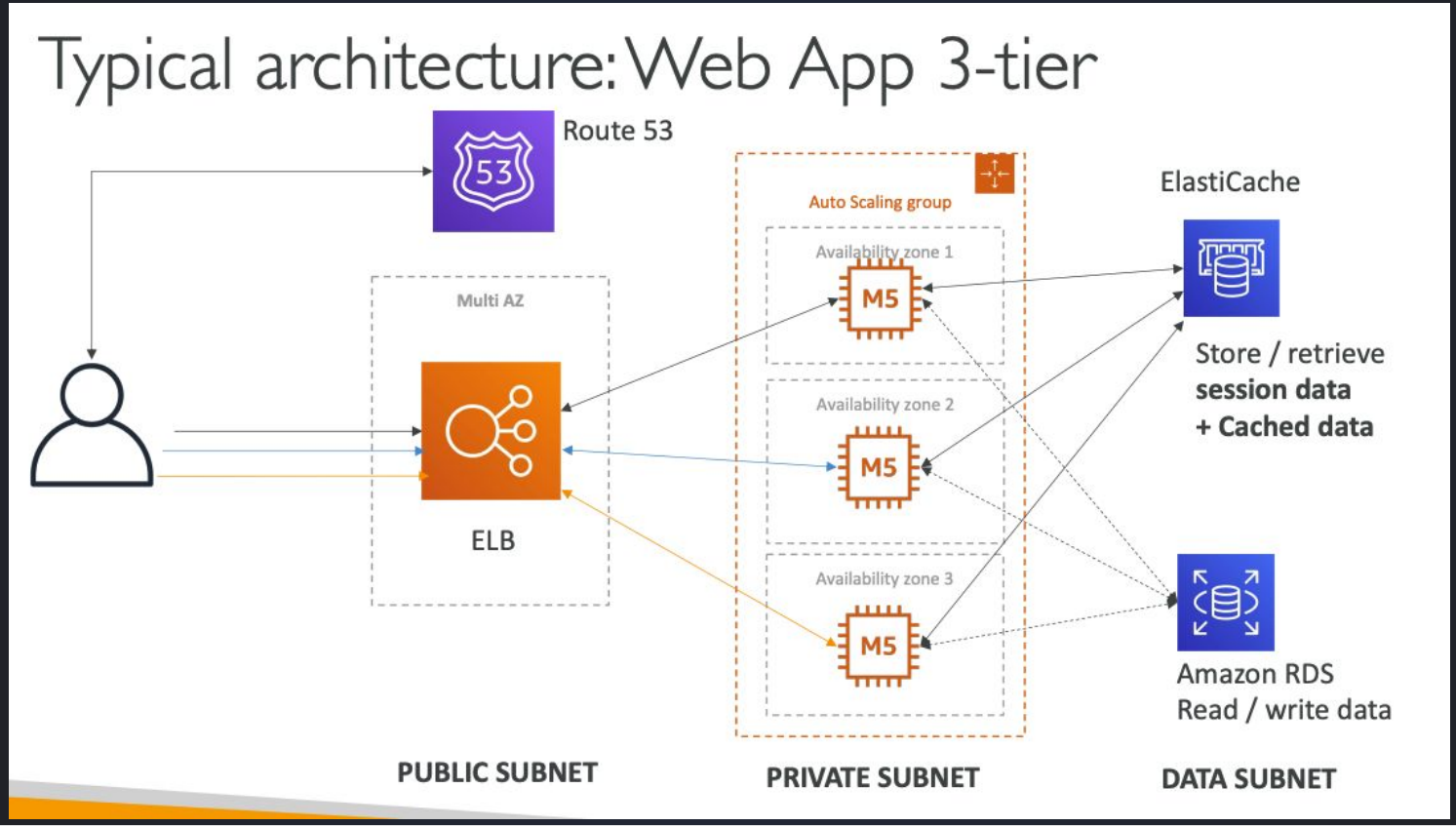
Instantiating Applications quickly

- 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!

Typical architecture: Web App 3-tier



Developer problems on AWS

- Managing infrastructure
- Deploying Code
- Configuring all the databases, load balancers, etc
- Scaling concerns

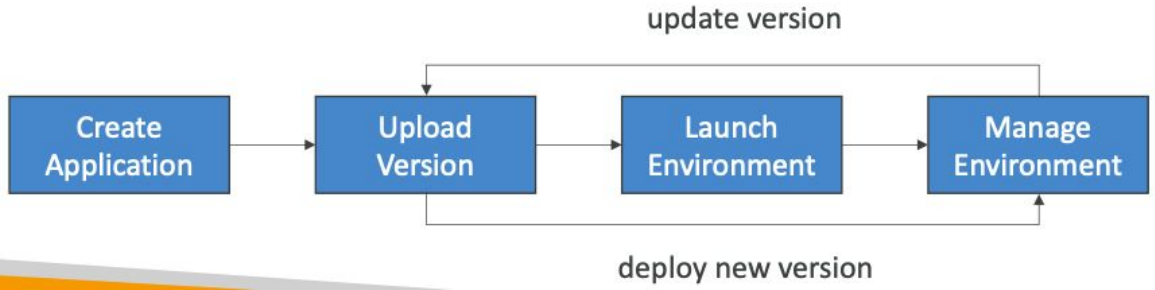
- Most web apps have the same architecture (ALB + ASG)
- All the developers want is for their code to run!
- Possibly, consistently across different applications and environments

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

Elastic Beanstalk – Components

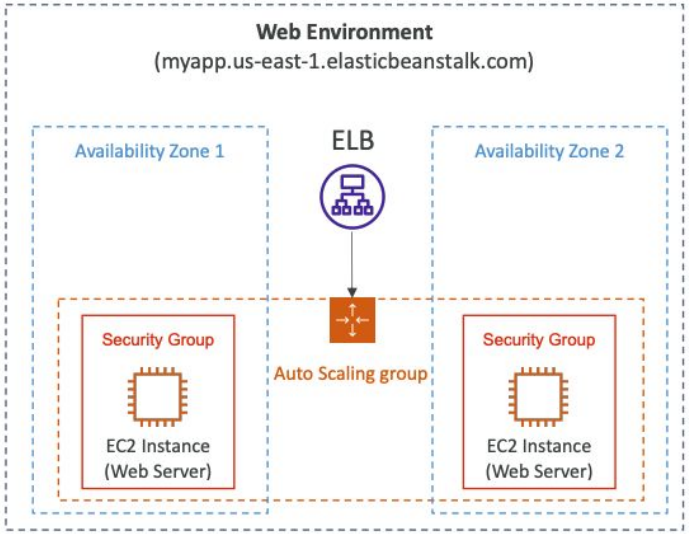
- **Application:** collection of Elastic Beanstalk components (environments, versions, configurations, …)
- **Application Version:** an iteration of your application code
- Environment
  - Collection of AWS resources running an application version (only one application version at a time)
  - **Tiers:** Web Server Environment Tier & Worker Environment Tier
  - You can create multiple environments (dev, test, prod, …)

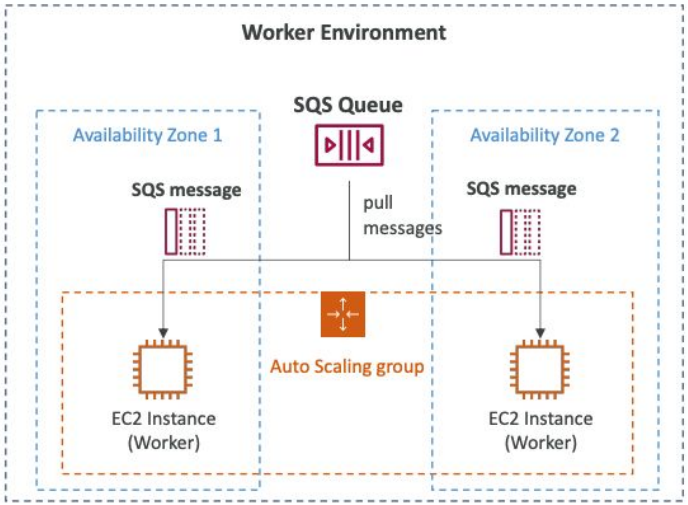


Elastic Beanstalk – Supported Platforms

- Go
- Java SE
- Java with Tomcat
- .NET Core on Linux
- .NET on Windows Server
- Node.js
- PHP
- Python
- Ruby
- Packer Builder
- Single Container Docker
- Multi-container Docker
- Preconfigured Docker

Web Server Tier vs. Worker Tier



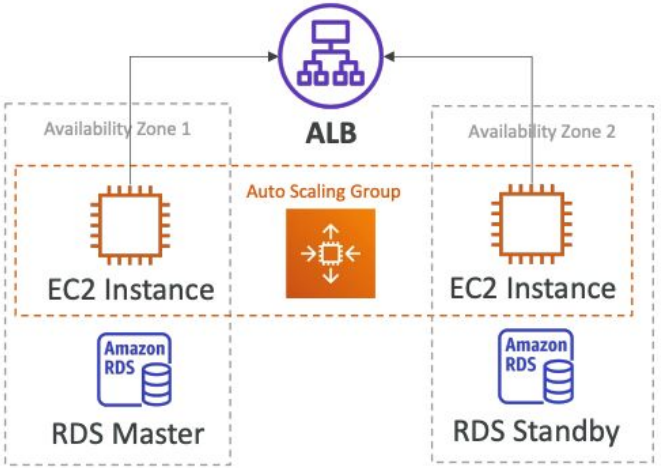


- Scale based on the number of SQS messages
- Can push messages to SQS queue from another Web Server Tier

Elastic Beanstalk Deployment Modes

Single Instance
Great for dev

High Availability with Load Balancer
Great for prod



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Data store types

Data store models

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- Block storage
- Object storage
- File storage
- Relational database
- Key/value stores
- In-Memory database
- Document database
- Graph database
- Timeseries database

Block store

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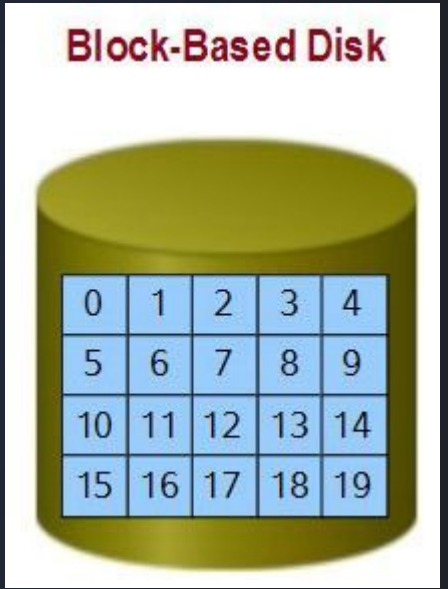
- Data is typically stored on device in fixed-sized blocks (512/4096 bytes)
- Stored without any higher-level metadata, format, type or ownership
- Accessed by operating system as mounted drive volumes
- Applications/file systems decide how blocks are accessed, combined and modified



File storage

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- File collaboration (Shareable)
- Centralized control of file network
- Data replication
- NFS
- NAS, SAN

Object storage

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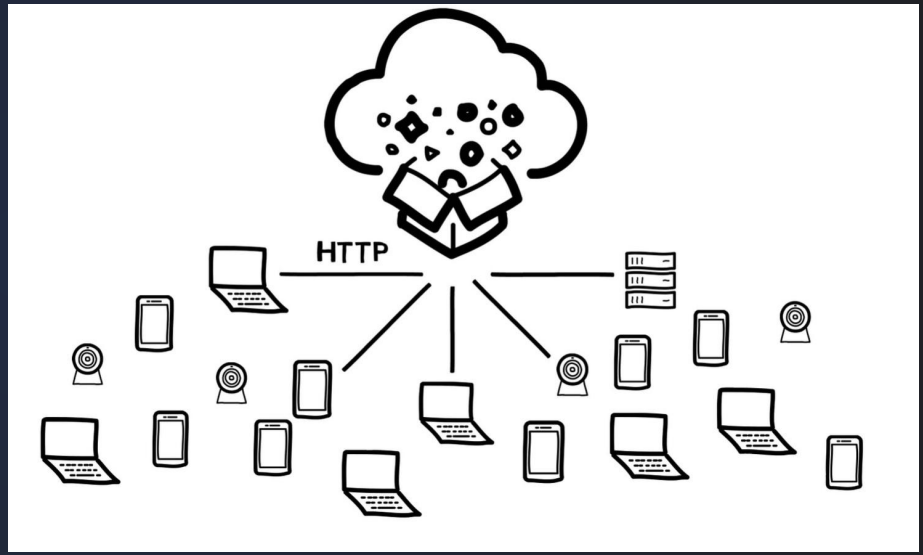
Object storage is optimized for storing and retrieving large binary objects (images, files, video and audio streams, large application data objects and documents, virtual machine disk images). Large data files are also popularly used in this model, for example, delimiter file (CSV), parquet, and ORC. Object stores can manage extremely large amounts of unstructured data.



Relational Database

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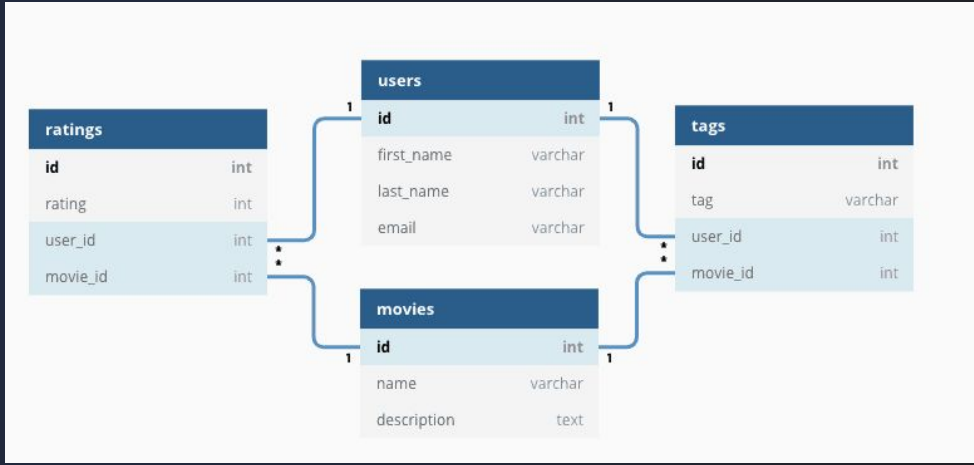
Relational databases organize data as a series of two-dimensional tables with rows and columns. Most vendors provide a dialect of the Structured Query Language (SQL) for retrieving and managing data. An RDBMS typically implements a transactionally consistent mechanism that conforms to the ACID (Atomic, Consistent, Isolated, Durable) model for updating information.



Key/Value store

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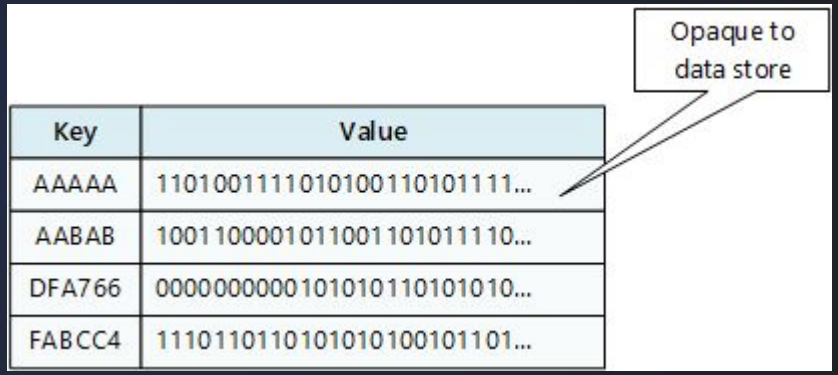
A key/value store associates each data value with a unique key. Most key/value stores only support simple query, insert, and delete operations. To modify a value (either partially or completely), an application must overwrite the existing data for the entire value. In most implementations, reading or writing a single value is an atomic operation.



In-Memory database

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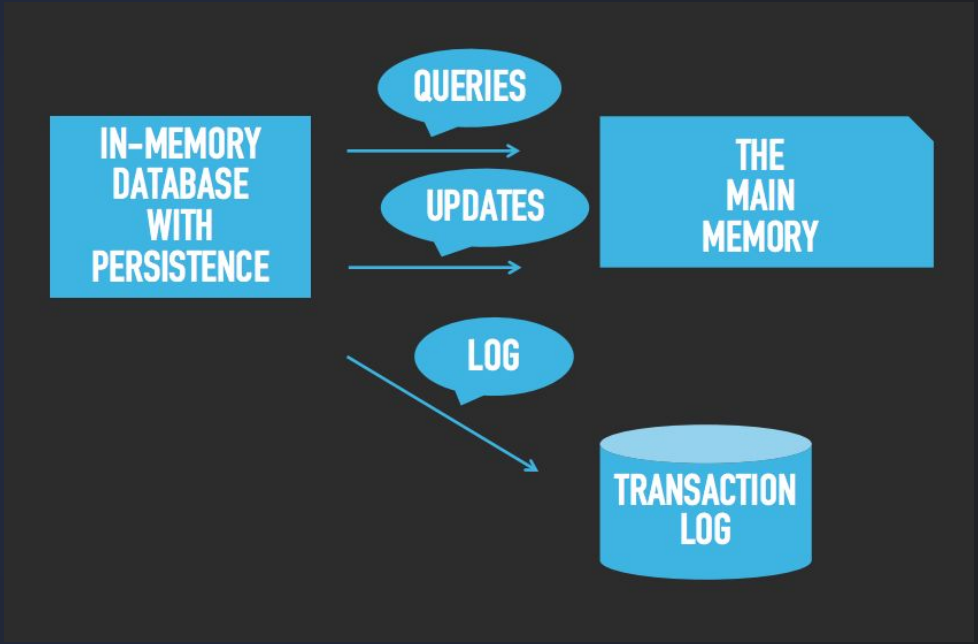
An in-memory database is a type of purpose-built database that relies primarily on memory for data storage, in contrast to databases that store data on disk or SSDs. In-memory databases are designed to attain minimal response time by eliminating the need to access disks.



Document database

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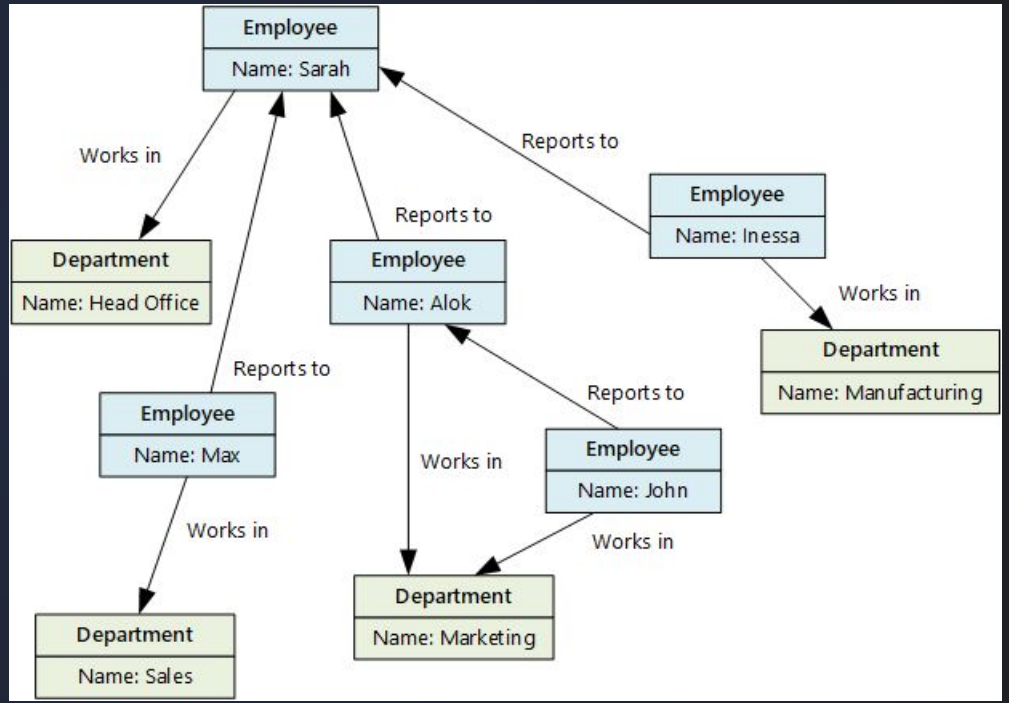
A document database stores a collection of documents, where each document consists of named fields and data. The data can be simple values or complex elements such as lists and child collections. Documents are retrieved by unique keys.
Typically, a document contains the data for single entity, such as a customer or an order. A document may contain information that would be spread across several relational tables in an RDBMS. Documents don't need to have the same structure. Applications can store different data in documents as business requirements change.

Key	Document
1001	{ "CustomerID": 99, "OrderItems": [{ "ProductID": 2010, "Quantity": 2, "Cost": 520 }, { "ProductID": 4365, "Quantity": 1, "Cost": 18 }], "OrderDate": "04/01/2017" }
1002	{ "CustomerID": 220, "OrderItems": [{ "ProductID": 1285, "Quantity": 1, "Cost": 120 }], "OrderDate": "05/08/2017" }

Graph database

A graph database stores two types of information, nodes and edges. Edges specify relationships between nodes. Nodes and edges can have properties that provide information about that node or edge, similar to columns in a table. Edges can also have a direction indicating the nature of the relationship.
Graph databases can efficiently perform queries across the network of nodes and edges and analyze the relationships between entities. The following diagram shows an organization's personnel database structured as a graph. The entities are employees and departments, and the edges indicate reporting relationships and the departments in which employees work.



Timeseries database

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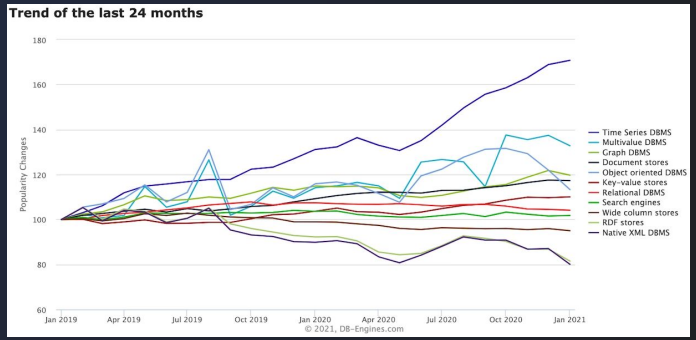
Time series data is a set of values organized by time. Time series databases typically collect large amounts of data in real time from a large number of sources. Updates are rare, and deletes are often done as bulk operations. Although the records written to a time-series database are generally small, there are often a large number of records, and total data size can grow rapidly.

Measurement Time	Air Quality Index (AQI)	The density of PM2.5
2018/01/01 00:00	156	45
2018/01/01 01:00	101	29
2018/01/01 02:00	97	19
…	…	…
2018/12/31 21:00	133	34
2018/12/31 22:00	135	36
2018/12/31 23:00	141	43



Many database types so far

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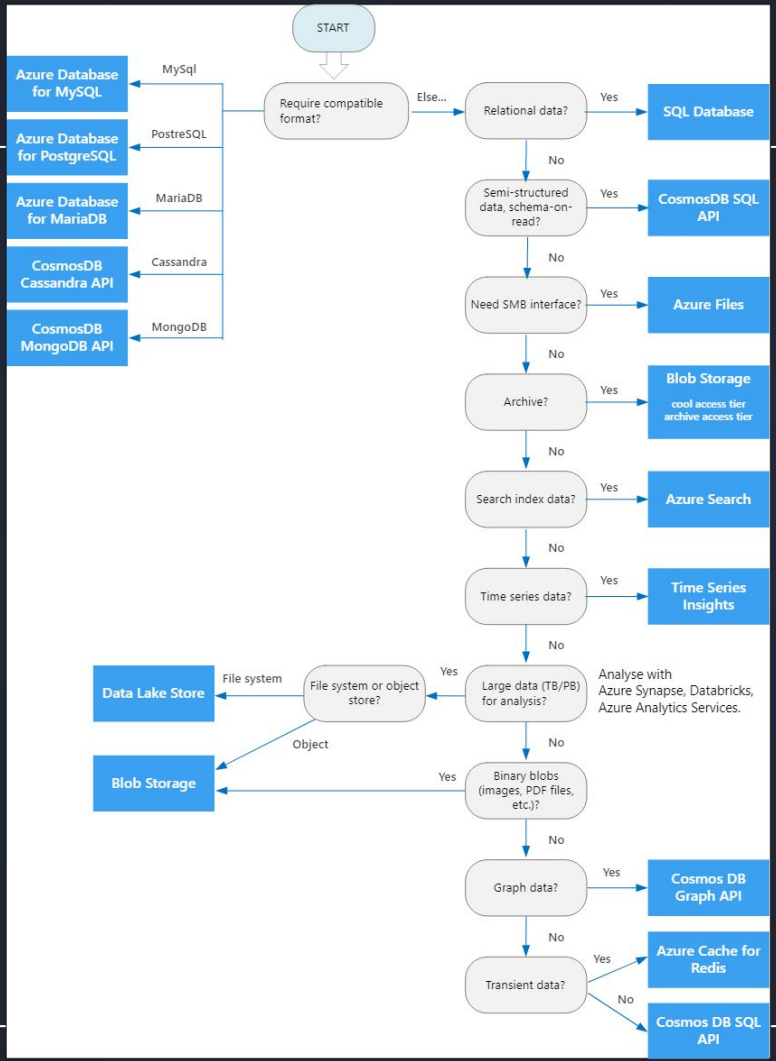
- Data analytics
- Column-family databases
- Search engine databases



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More...

Block storage

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PROS
- Cheap
- Easy to use

CONS
- Not shareable
- Can not use in Cloud

Block storage - SAN

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PROS
- High Performance
- Great for many R/W operations

CONS
- Expensive
- Complex
- Not scalable

File storage - SAN

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PROS
- File collaboration (Shareable)
- Centralized control of file network
- Data replication

CONS
- Performance affected by network traffic
- Expensive
- Restricted access

Object storage

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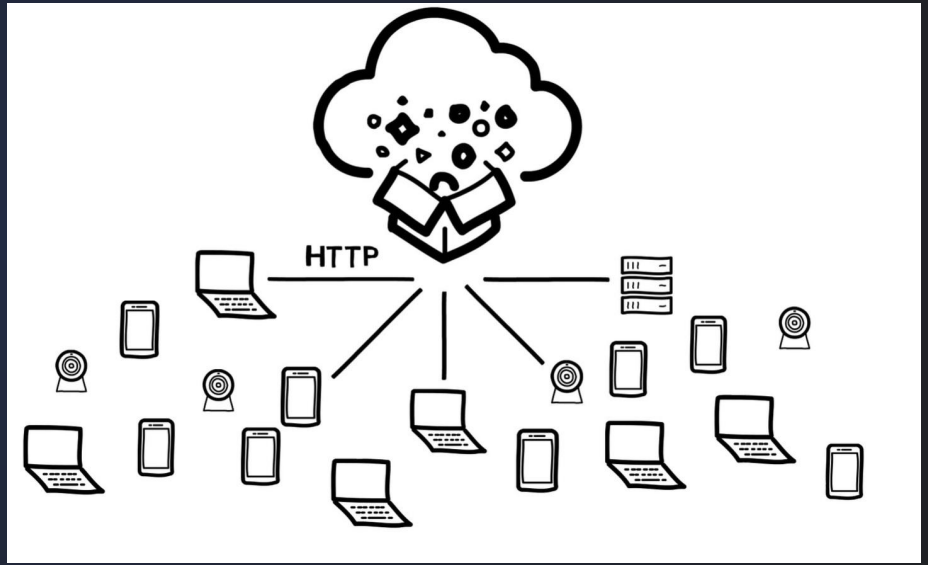
PROS
- Reliable
- High performance
- High scalable
- Any source accessible (Shareable)
- Great for unstructured data
- Any network protocol
- Low TCO
- No need OS

CONS
- Speed



Difference

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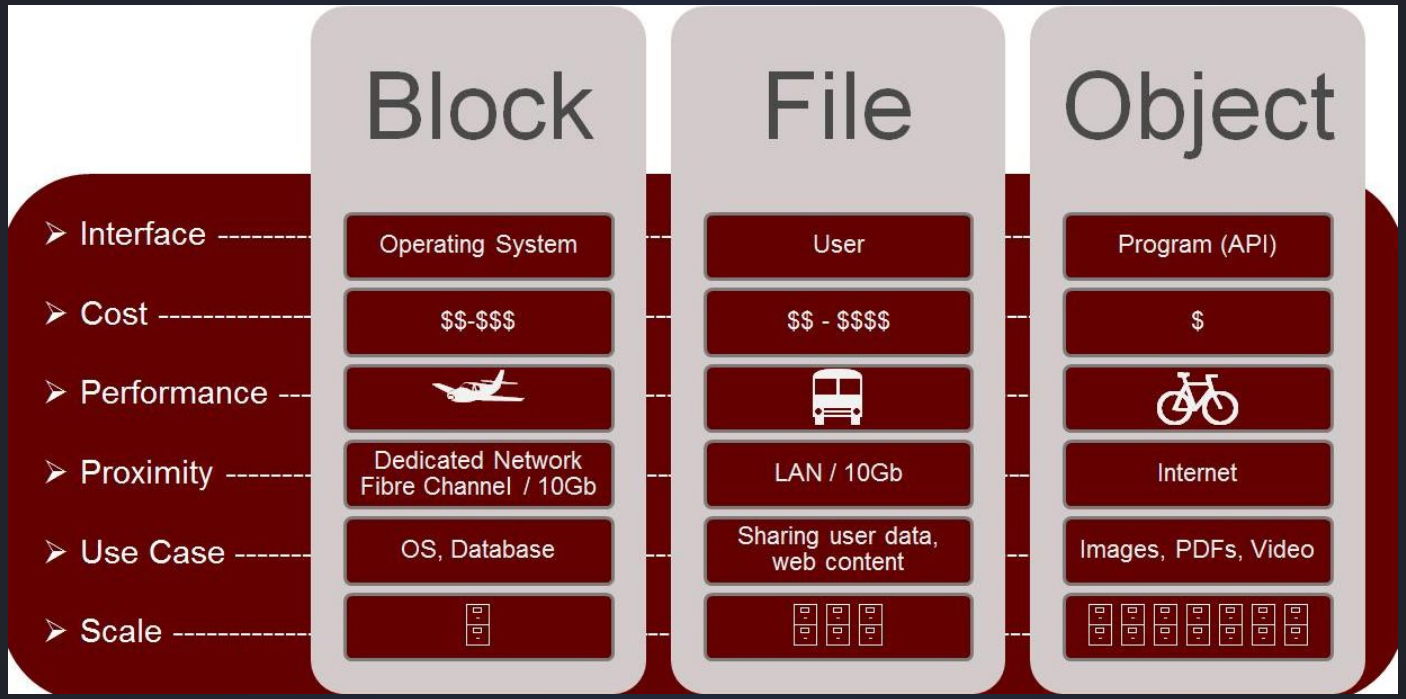

Difference

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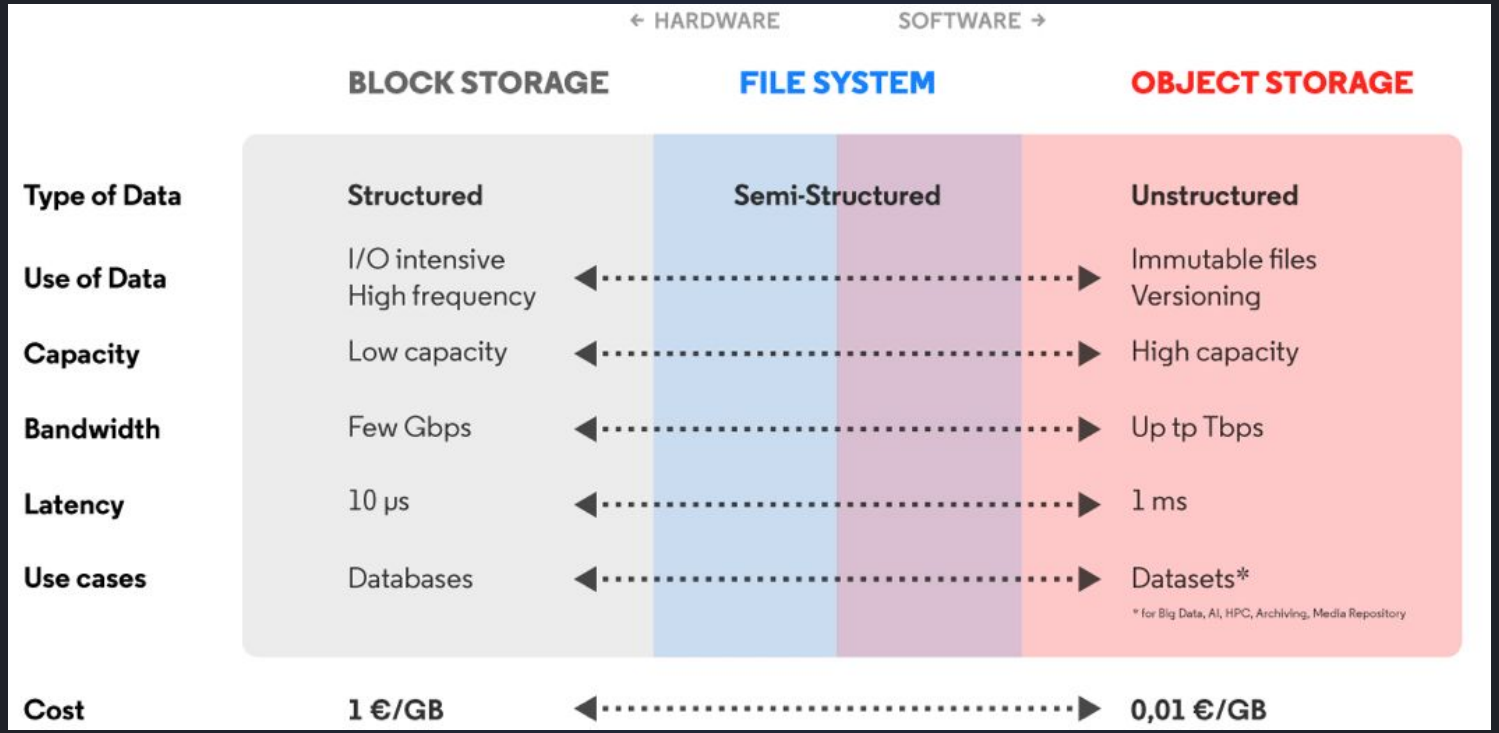

Cloud storage

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Block Storage	EBS	Disks	Persistent Disk	Volumes
File Storage	EFS	Files	Filestore	
Object Storage	S3	Blobs	Cloud Storage	Spaces

Distributed storage

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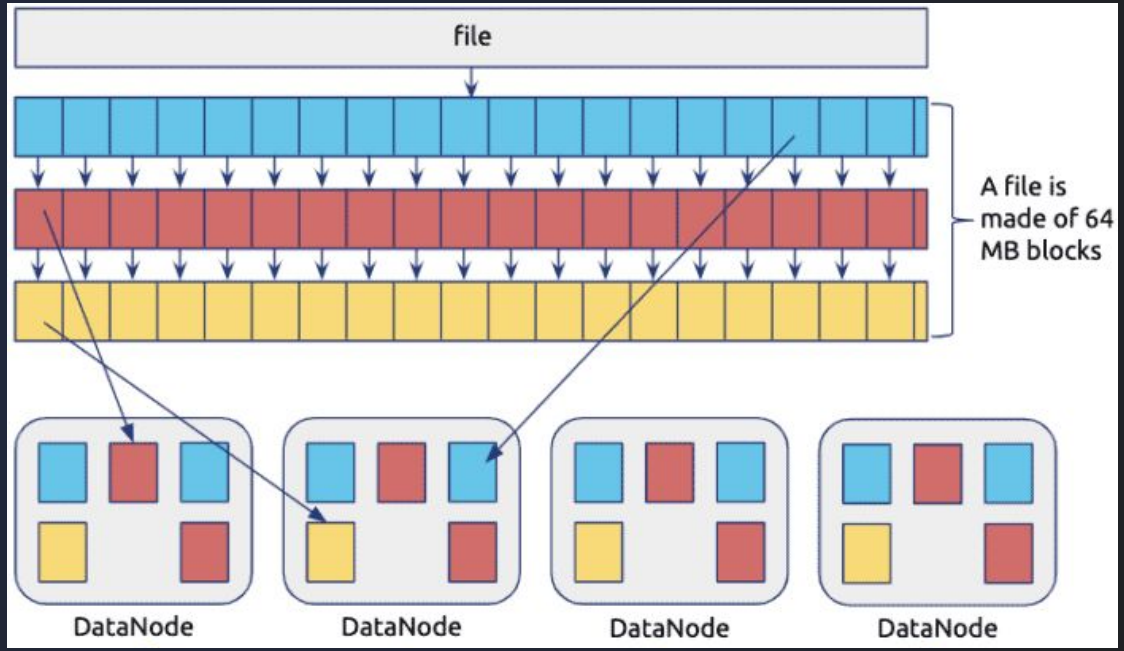
- The same piece of dta may be stored in multiple locations

- Multiple process may read and write the same data at nearly the same time



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AWS S3

Users

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AWS S3

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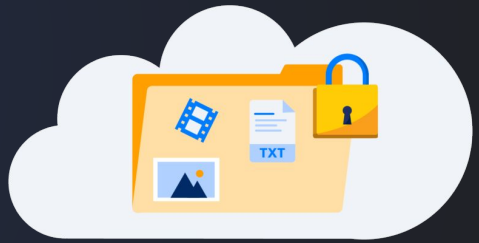
Simple Storage Service - AWS-н хамгийн анхны үйлчилгээ.

Amazon’s secure, durable, highly available object storage service.
For serving and storing static files.
Үйлдлийн систем суулгахгүй, Database биш, **Зөвхөн файл хадгална**

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 web services S3

Buckets

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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

Amazon S3 - 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

S3 Bucket with Objects

Amazon S3 – Objects (cont.)

- 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)

Path

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fibocloud.s3.amazonaws.com (default region us-east-1)
fibocloud.ap-east-1.amazonaws.com

When you upload a file in S3, you will receive an HTTP 200 code if the upload was successful.
By Default, all the Objects in the bucket are private.

Features

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- Storage tier
- Lifecycle management
- Versioning
- Encryption
- MFA delete
- ACL + Bucket policy
- …

Durability

Storage class

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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

Storage class

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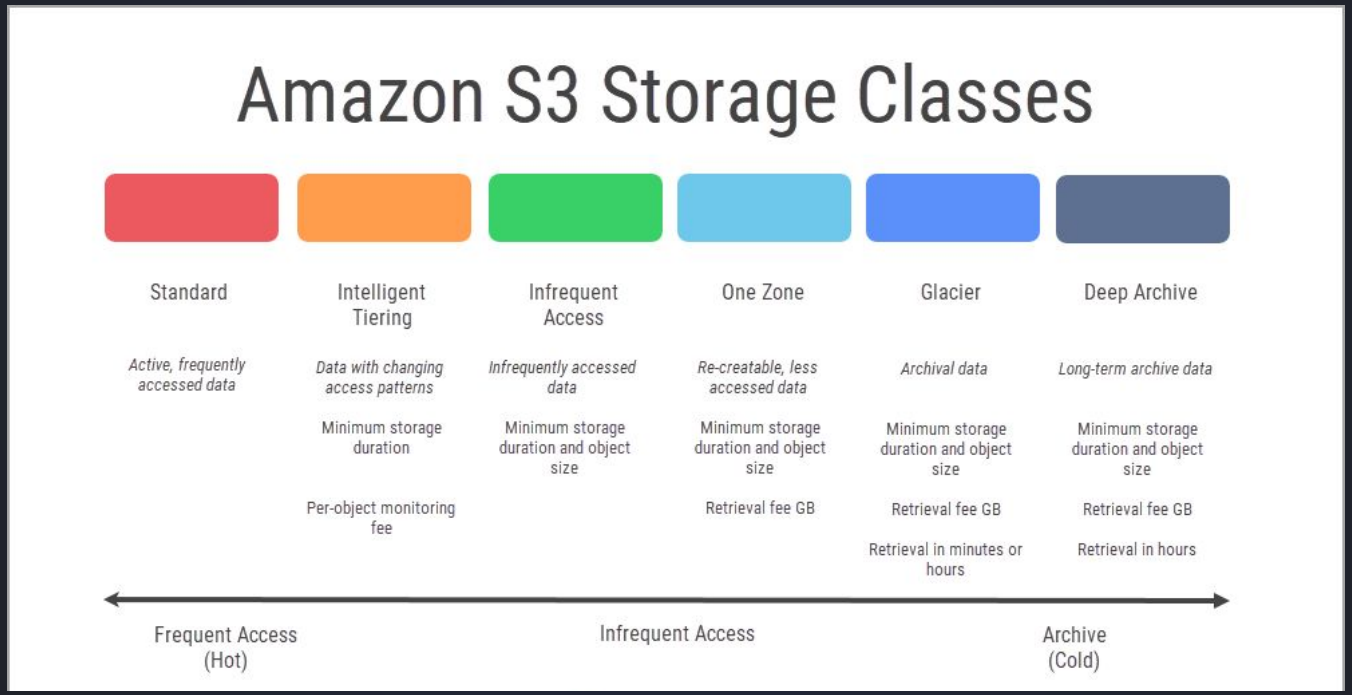

	S3 Standard	S3 Intelligent-Tiering*	S3 Standard-IA	S3 One Zone-IA†	S3 Glacier	S3 Glacier Deep Archive**
Designed for durability	99.999999999% (11 9's)	99.999999999% (11 9's)	99.999999999% (11 9's)	99.999999999% (11 9's)	99.999999999% (11 9's)	99.999999999% (11 9's)
Designed for availability	99.99%	99.9%	99.9%	99.5%	N/A	N/A
Availability SLA	99.9%	99%	99%	99%	N/A	N/A
Availability Zones	≥3	≥3	≥3	1	≥3	≥3
Minimum capacity charge per object	N/A	N/A	128KB	128KB	40KB	40KB
Minimum storage duration charge	N/A	30 days	30 days	30 days	90 days	180 days
Retrieval fee	N/A	N/A	per GB retrieved	per GB retrieved	per GB retrieved	per GB retrieved
First byte latency	milliseconds	millseconds	milliseconds	milliseconds	select minutes or hours	select hours

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S3 Storage Classes – Price Comparison Example: us-east-1

	Standard	Intelligent-Tiering	Standard-IA	One Zone-IA	Glacier Instant Retrieval	Glacier Flexible Retrieval	Glacier Deep Archive
Storage Cost (per GB per month)	$0.023	$0.0025 - $0.023	$0.0125	$0.01	$0.004	$0.0036	$0.00099
Retrieval Cost (per 1000 request)	**GET:** $0.0004 **POST:** $0.005	**GET:** $0.0004 **POST:** $0.005	**GET:** $0.001 **POST:** $0.01	**GET:** $0.001 **POST:** $0.01	**GET:** $0.01 **POST:** $0.02	**GET:** $0.0004 **POST:** $0.03 **Expedited:** $10 **Standard:** $0.05 **Bulk:** free	**GET:** $0.0004 **POST:** $0.05 **Standard:** $0.10 **Bulk:** $0.025
Retrieval Time	Instantaneous					**Expedited** (1 – 5 mins) **Standard** (3 – 5 hours) Bulk (5 – 12 hours)	**Standard** (12 hours) **Bulk** (48 hours)
Monitoring Cost (pet 1000 objects)		$0.0025					

https://aws.amazon.com/s3/pricing/

Lifecycle rule

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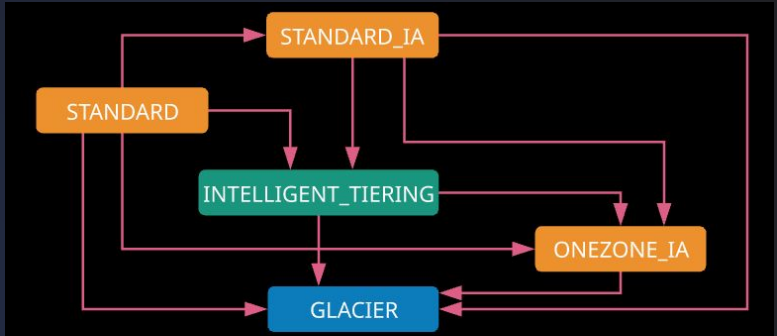
Amazon S3 – Lifecycle Rules

- **Transition Actions** – configure objects to transition to another storage class
  - Move objects to Standard IA class 60 days after creation
  - Move to Glacier for archiving after 6 months
- **Expiration actions** – configure objects to expire (delete) after some time
  - Access log files can be set to delete after a 365 days
  - Can be used to delete old versions of files (if versioning is enabled)
  - Can be used to delete incomplete Multi-Part uploads
- Rules can be created for a certain prefix (example: *s3://mybucket/mp3/**)
- Rules can be created for certain objects Tags (example: *Department: Finance*)



Objects smaller than 128 KB cannot be transitioned into **INTELLIGENT_TIERING**. Objects must be in the original storage class for a minimum of 30 days before transitioning them to either of the IA storage tiers. Instead of transitioning between tiers, objects can be configured to expire after certain time periods. At the point of expiry, they are deleted from the bucket.

Objects can be archived into Glacier using lifecycle configurations. The objects remain inside S3, managed from S3, but Glacier is used for storage. Objects can be restored into S3 for temporary periods of time — after which, they are deleted. If objects are encrypted, they remain encrypted during their transition to Glacier or temporary restoration into S3.

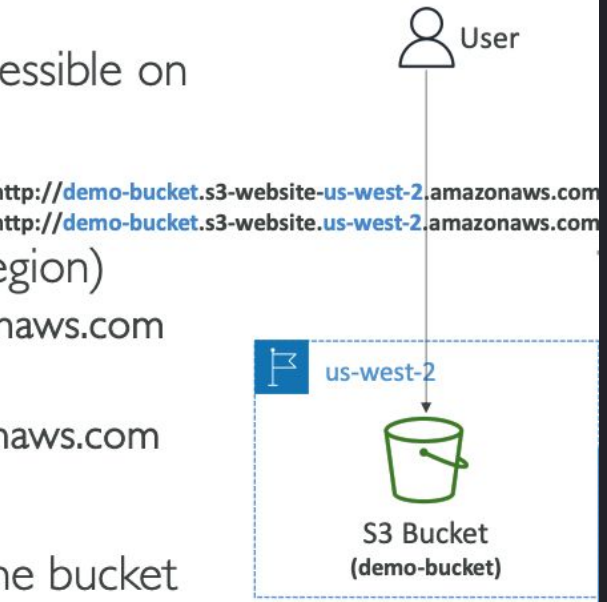
Amazon S3 – Static Website Hosting

- S3 can host static websites and have them accessible on the Internet

- The website URL will be (depending on the region)
  - http://*bucket-name*.s3-website-*aws-region*.amazonaws.com

  OR
  - http://*bucket-name*.s3-website.*aws-region*.amazonaws.com

- If you get a **403 Forbidden** error, make sure the bucket policy allows public reads!



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AWS S3 Advanced

S3 performance

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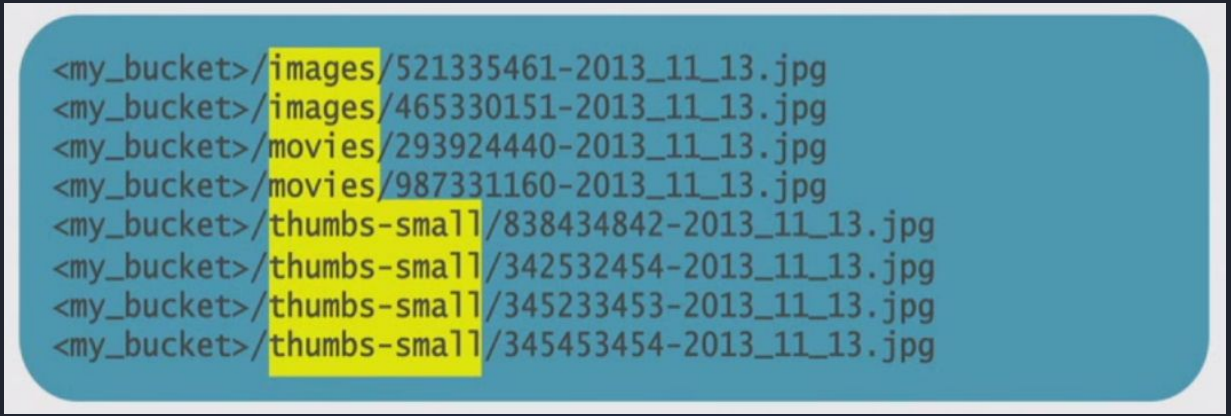
S3 Prefix



S3 performance

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Your applications can easily achieve thousands of transactions per second in request performance when uploading and retrieving storage from Amazon S3. Amazon S3 automatically scales to high request rates. For example, your application can achieve at least **3,500 PUT/COPY/POST/DELETE** or **5,500 GET/HEAD requests per second** per prefix in a bucket. There are no limits to the number of prefixes in a bucket. You can increase your read or write performance by parallelizing reads. For example, if you create 10 prefixes in an Amazon S3 bucket to parallelize reads, you could scale your read performance to 55,000 read requests per second. Similarly, you can scale write operations by writing to multiple prefixes.

Бусад service performance consideration бас тооцох хэрэгтэй. Жишээ нь: **KMS**

S3 performance

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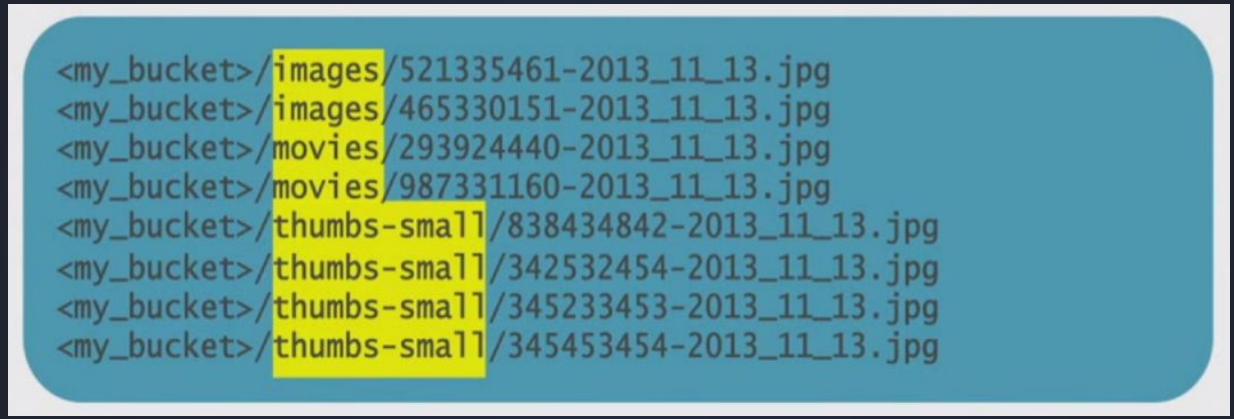
S3 Prefix



Can be used for sorting

Multipart upload

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Uploads to S3 are generally done using the S3 console, the CLI, or directly using the APIs. Uploads either use a single operation (known as a single PUT upload) or multipart upload.

Single PUT Upload

Object is uploaded in a single stream of data

Limit of **5 GB**, can cause performance issues, and if the upload fails the **whole upload** fails

Multipart upload

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Multipart Upload

An object is broken up into parts (up to **10,000**), each part is **5 MB** to **5 GB**, and the last part can be less (the remaining data)

Multipart upload is **faster** (parallel uploads), and the individual parts can fail and be retried individually. AWS recommends multipart for anything over **100 MB**, but it's required for anything beyond **5 GB**.

S3 Byte-range fetches

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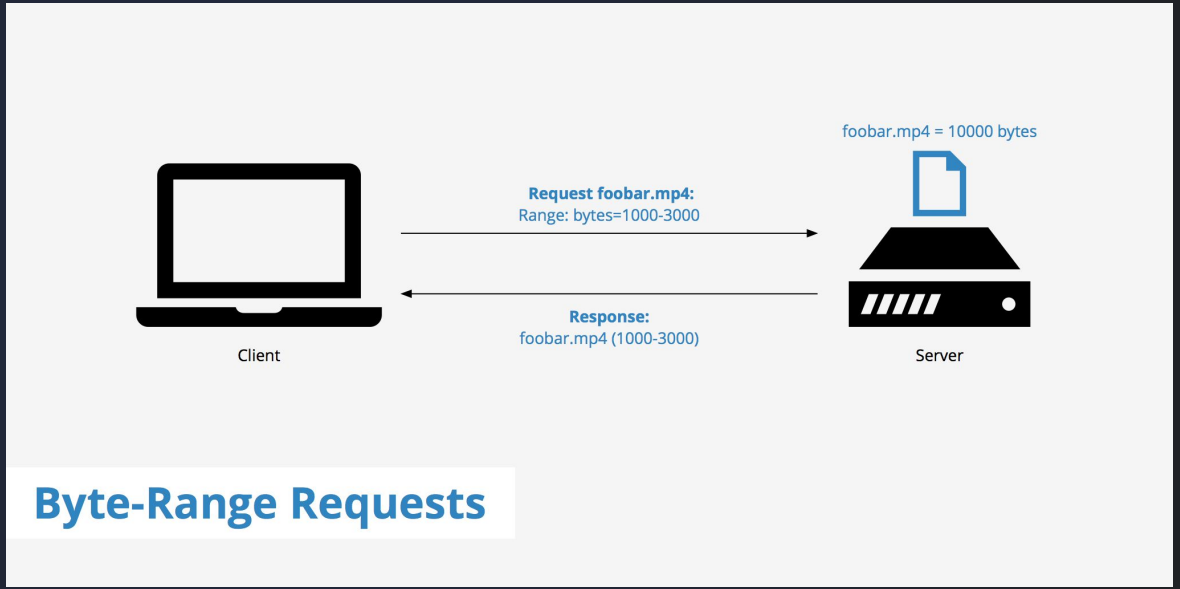
Speed up downloads
Partial amounts of file



S3 Select

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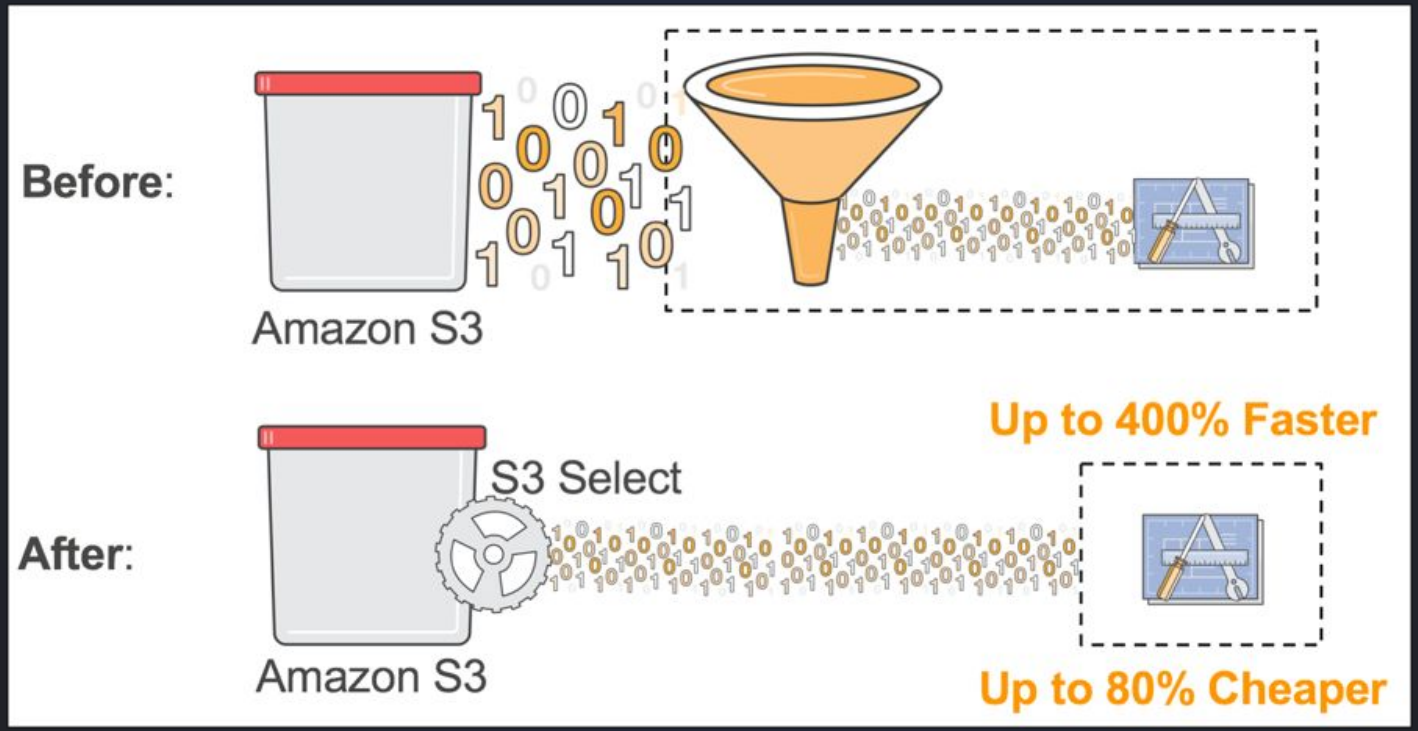
https://aws.amazon.com/blogs/aws/s3-glacier-select/



S3 Share bucket to another account

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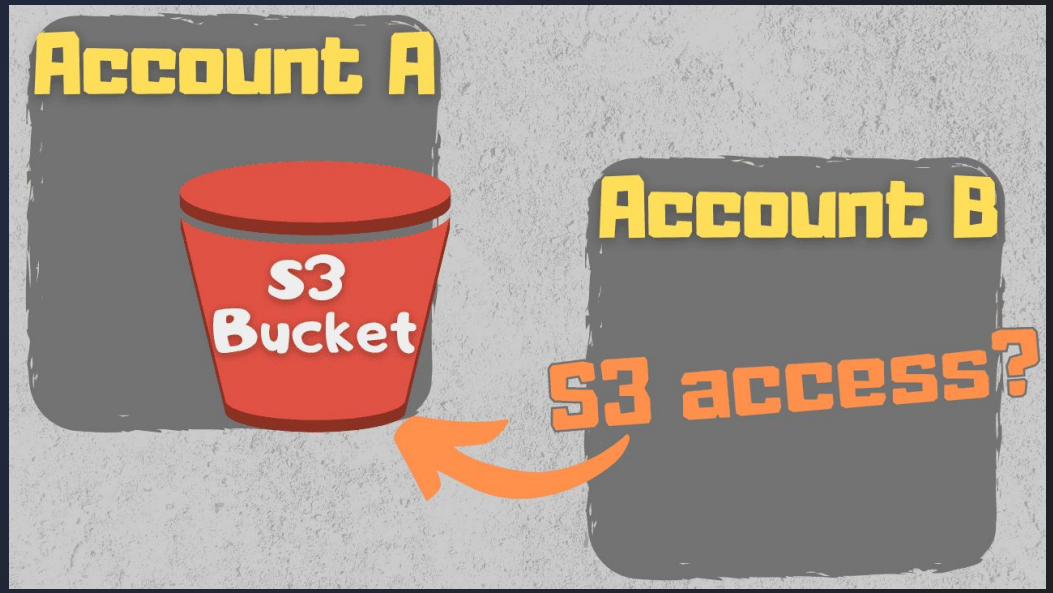
1. Bucket policy or IAM
2. Bucket ACL and IAM
3. Cross account IAM roles

https://aws.amazon.com/premiumsupport/knowledge-center/cross-account-access-s3/



Bucket versioning

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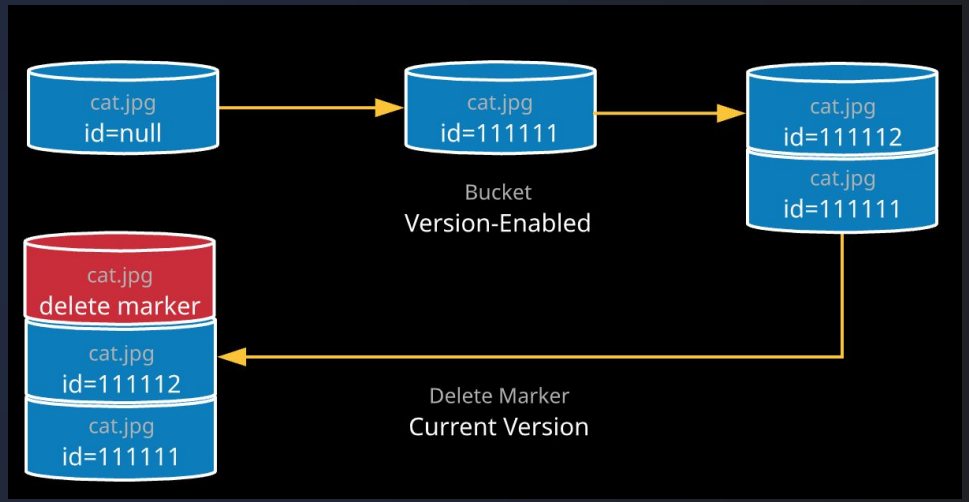
Versioning can be enabled on an S3 bucket. Once enabled, any operations that would otherwise modify objects generate new versions of that original object. Once bucket is version-enabled, it can never be fully switched off - only **suspended**

- Billed for all versions of object
- Delete marker
- Object ID and a version ID
- Specific versions can be deleted
- Can be used as a backup
- Bucket level
- Integrated with lifecycle rule
- MFA capability
- Specific version to be made a public
- Latest version turns into public



Cross region replication

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- Version must be enabled both source and destination bucket
- Existing files are not replicated
- Delete markers are not replicated
- Deleting individual versions or delete markers won't be replicated

S3 Transfer acceleration

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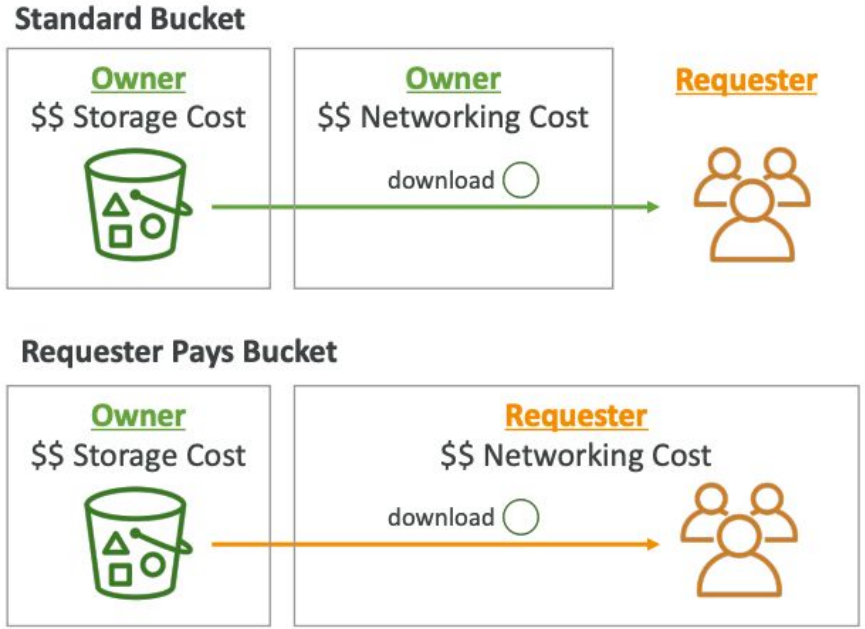
- CloudFront edge location-оор дамжуулж upload хийнэ
- https://s3-accelerate-speedtest.s3-accelerate.amazonaws.com/en/accelerate-speed-comparsion.html

S3 – Requester Pays

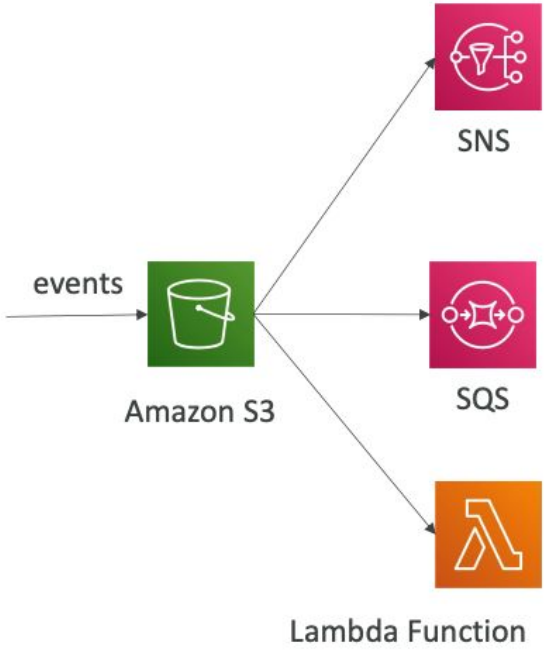
- In general, bucket owners pay for all Amazon S3 storage and data transfer costs associated with their bucket
- With Requester Pays buckets, the requester instead of the bucket owner pays the cost of the request and the data download from the bucket
- Helpful when you want to share large datasets with other accounts
- The requester must be authenticated in AWS (cannot be anonymous)



S3 Event Notifications

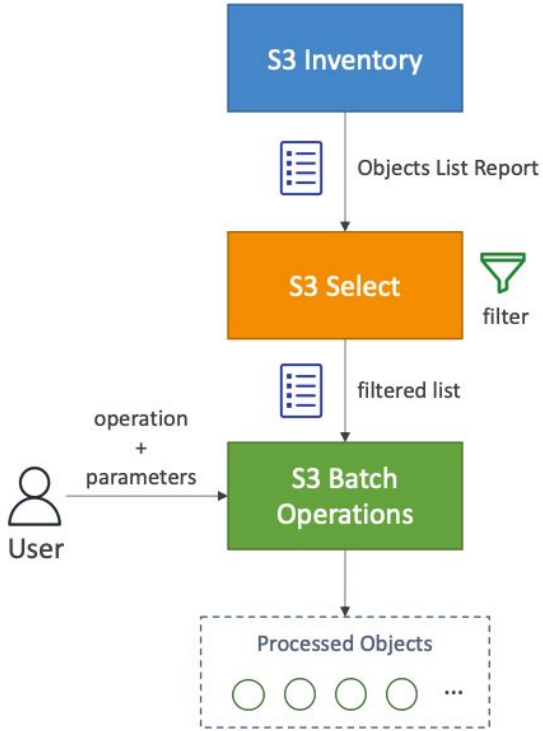
- S3:ObjectCreated, S3:ObjectRemoved, S3:ObjectRestore, S3:Replication…
- Object name filtering possible (*.jpg)
- Use case: generate thumbnails of images uploaded to S3
- Can create as many "S3 events" as desired

- S3 event notifications typically deliver events in seconds but can sometimes take a minute or longer



S3 Batch Operations

- Perform bulk operations on existing S3 objects with a single request, example:
  - Modify object metadata & properties
  - Copy objects between S3 buckets
  - **Encrypt un-encrypted objects**
  - Modify ACLs, tags
  - Restore objects from S3 Glacier
  - Invoke Lambda function to perform custom action on each object
- A job consists of a list of objects, the action to perform, and optional parameters
- S3 Batch Operations manages retries, tracks progress, sends completion notifications, generate reports …
- **You can use S3 Inventory to get object list and use S3 Select to filter your objects**



AWS S3 Static Website

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https://docs.aws.amazon.com/AmazonS3/latest/userguide/WebsiteEndpoints.html

```
{
  "Version":"2012-10-17",
  "Statement":[{
     "Sid":"PublicReadGetObject",
     "Effect":"Allow",
     "Principal": "*",
     "Action":["s3:GetObject"],
     "Resource":["arn:aws:s3:::<MY_BUCKET>/*"]
  }]
}
```

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https://www.allthingsdistributed.com/articles.html
https://www.vox.com/2017/3/2/14792636/amazon-aws-internet-outage-cause-human-error-incorrect-command
https://www.theregister.com/2017/03/01/aws_s3_outage/
https://www.npr.org/sections/thetwo-way/2017/03/03/518322734/amazon-and-the-150-million-typo

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AWS S3 Security

Amazon S3 – Security

- User-Based
  - **IAM Policies** – which API calls should be allowed for a specific user from IAM
- Resource-Based
  - **Bucket Policies** – bucket wide rules from the S3 console - allows cross account
  - **Object Access Control List (ACL)** – finer grain (can be disabled)
  - **Bucket Access Control List (ACL)** – less common (can be disabled)
- **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
  - Effect: Allow / Deny
  - Actions: Set of API to Allow or Deny
  - Principal: The account or user to apply the policy to

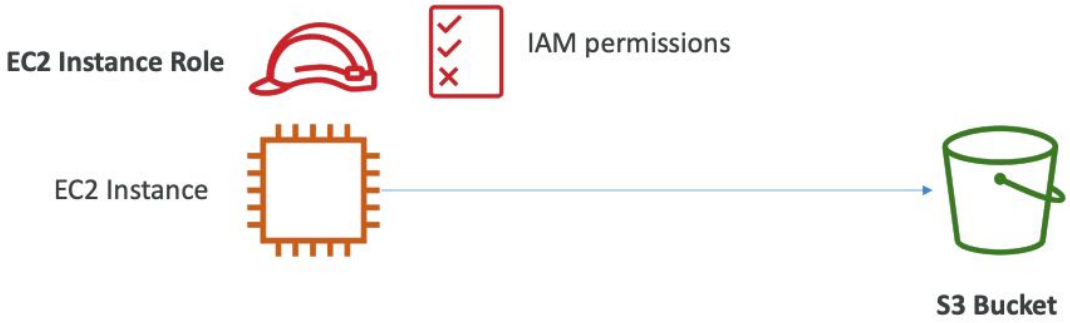
- Use S3 bucket for policy to:
  - Grant public access to the bucket
  - Force objects to be encrypted at upload
  - Grant access to another account (Cross Account)

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

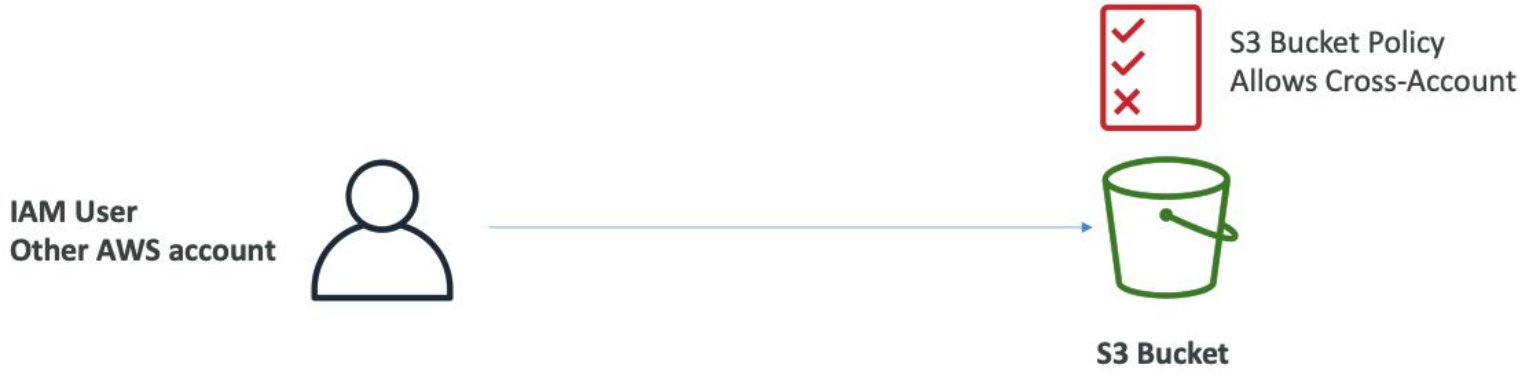
Example: Public Access - Use Bucket Policy

Example: User Access to S3 – IAM permissions

Example: EC2 instance access - Use IAM Roles



Advanced: Cross-Account Access – Use Bucket Policy



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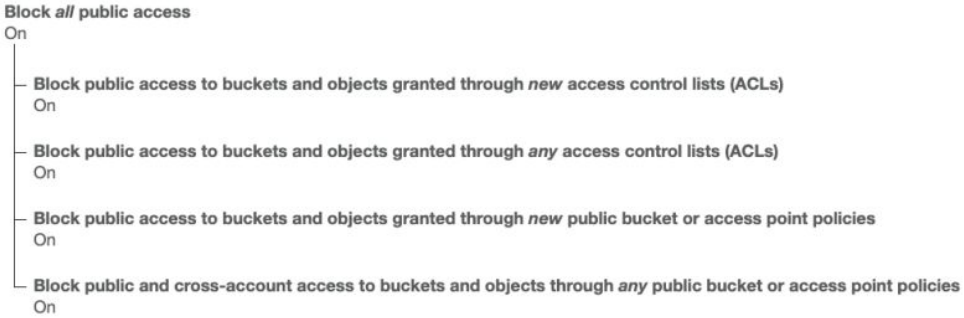
Bucket settings for Block Public Access



- 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

Object lock

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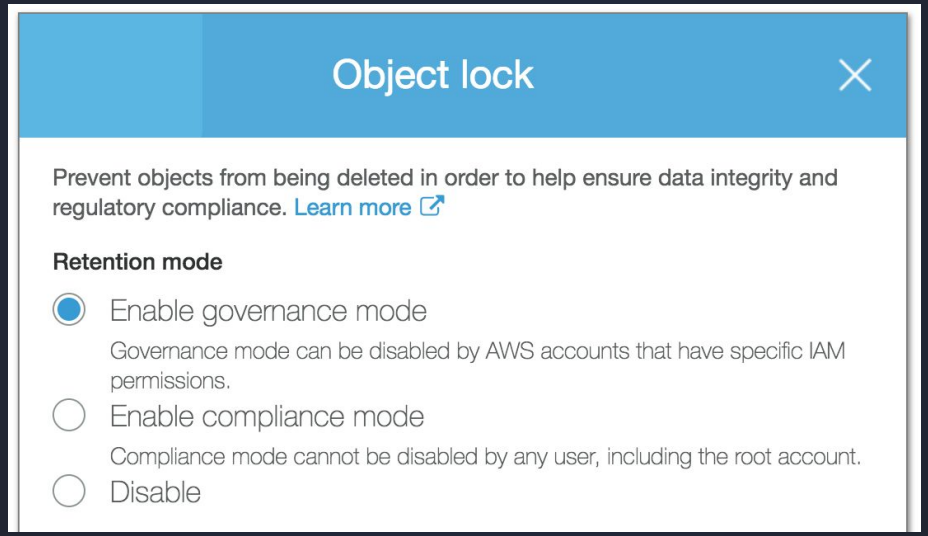

Vault lock

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https://docs.aws.amazon.com/amazonglacier/latest/dev/vault-lock.html

1. Initiate the lock by attaching a vault lock policy to your vault, which sets the lock to an in-progress state and returns a lock ID. While in the in-progress state, you have 24 hours to validate your vault lock policy before the lock ID expires.
2. Use the lock ID to complete the lock process. If the vault lock policy doesn't work as expected, you can stop the lock and restart from the beginning. For information on how to use the S3 Glacier API to lock a vault, see Locking a Vault by Using the Amazon S3 Glacier API.

Amazon S3 – Object Encryption

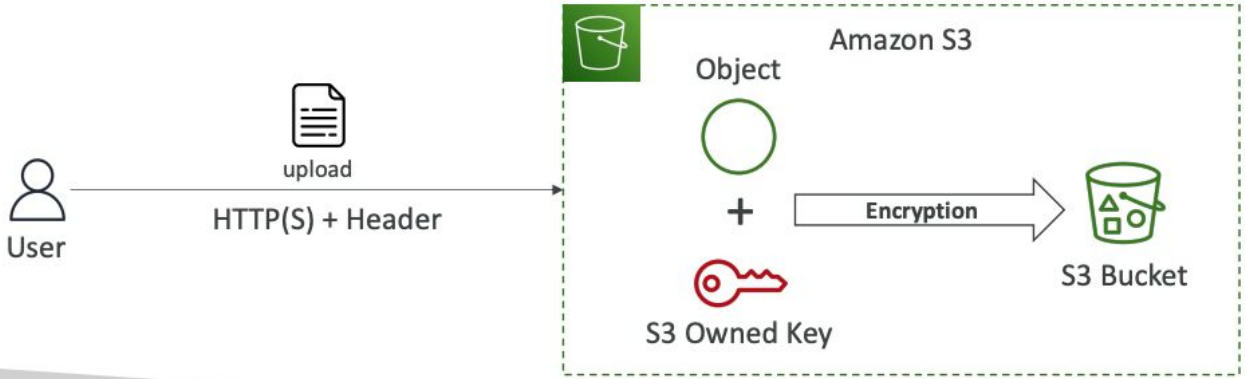
- You can encrypt objects in S3 buckets using one of 4 methods

- 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

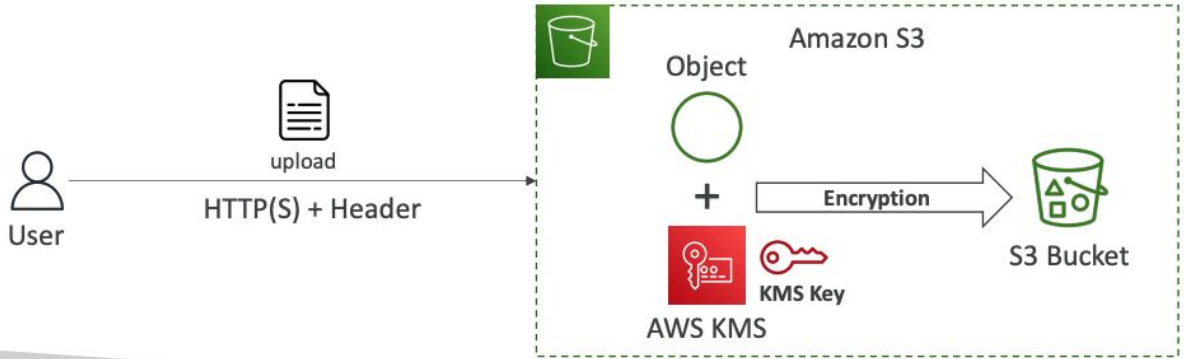
Amazon S3 Encryption – SSE-S3

- Encryption using keys handled, managed, and owned by AWS
- Object is encrypted server-side
- Encryption type is AES-256
- Must set header "x-amz-server-side-encryption": "AES256"
- Enabled by default for new buckets & new objects



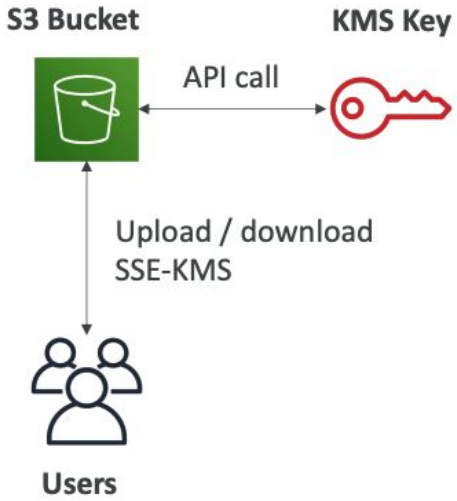
Amazon S3 Encryption – SSE-KMS

- Encryption using keys handled and managed by AWS KMS (Key Management Service)
- KMS advantages: user control + audit key usage using CloudTrail
- Object is encrypted server side
- Must set header **"x-amz-server-side-encryption": "aws:kms"**



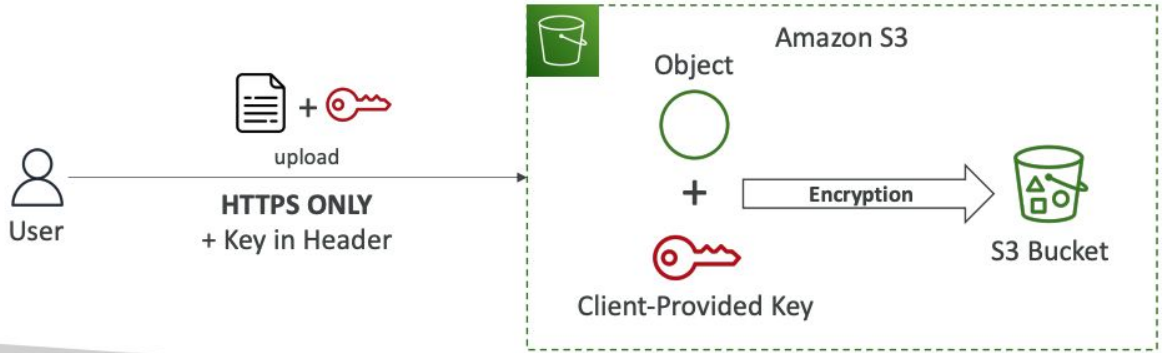
SSE-KMS Limitation

- If you use SSE-KMS, you may be impacted by the KMS limits
- When you upload, it calls the **GenerateDataKey** KMS API
- When you download, it calls the **Decrypt** KMS API
- Count towards the KMS quota per second (5500, 10000, 30000 req/s based on region)
- You can request a quota increase using the Service Quotas Console



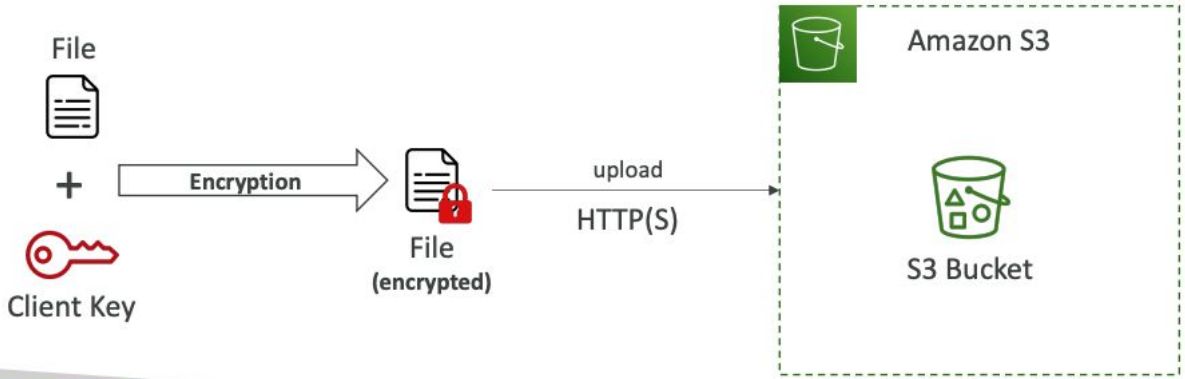
Amazon S3 Encryption – SSE-C

- Server-Side Encryption using keys fully managed by the customer outside of AWS
- Amazon S3 does **NOT** store the encryption key you provide
- **HTTPS must be used**
- Encryption key must provided in HTTP headers, for every HTTP request made



Amazon S3 Encryption – Client-Side Encryption

- Use client libraries such as **Amazon S3 Client-Side Encryption Library**
- Clients must encrypt data themselves before sending to Amazon S3
- Clients must decrypt data themselves when retrieving from Amazon S3
- Customer fully manages the keys and encryption cycle



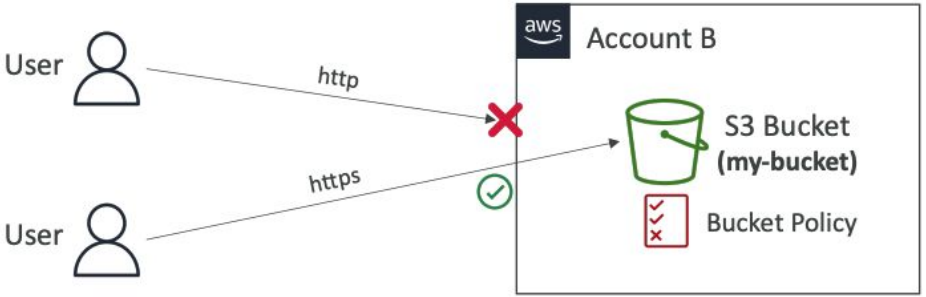
Amazon S3 – Encryption in transit (SSL/TLS)

- Encryption in flight is also called SSL/TLS

- Amazon S3 exposes two endpoints:
  - **HTTP Endpoint** – non encrypted
  - **HTTPS Endpoint** – encryption in flight

- HTTPS is recommended
- HTTPS is mandatory for SSE-C
- Most clients would use the HTTPS endpoint by default

Amazon S3 – Force Encryption in Transit aws:SecureTransport




```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Deny",
            "Principal": "*",
            "Action": "s3:GetObject",
            "Resource": "arn:aws:s3:::my-bucket/*",
            "Condition": {
                "Bool": {
                    "aws:SecureTransport": "false"
                }
            }
        }
    ]
}
```

Amazon S3 – Default Encryption vs. Bucket Policies

- SSE-S3 encryption is automatically applied to new objects stored in S3 bucket
- Optionally, you can "force encryption" using a bucket policy and refuse any API call to PUT an S3 object without encryption headers (SSE-KMS or SSE-C)

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Deny",
            "Action": "s3:PutObject",
            "Principal": "*",
            "Resource": "arn:aws:s3:::my-bucket/*",
            "Condition": {
                "StringNotEquals": {
                    "s3:x-amz-server-side-encryption": "aws:kms"
                }
            }
        }
    ]
}
```

```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Effect": "Deny",
            "Action": "s3:PutObject",
            "Principal": "*",
            "Resource": "arn:aws:s3:::my-bucket/*",
            "Condition": {
                "Null": {
                    "s3:x-amz-server-side-encryption-customer-algorithm": "true"
                }
            }
        }
    ]
}
```

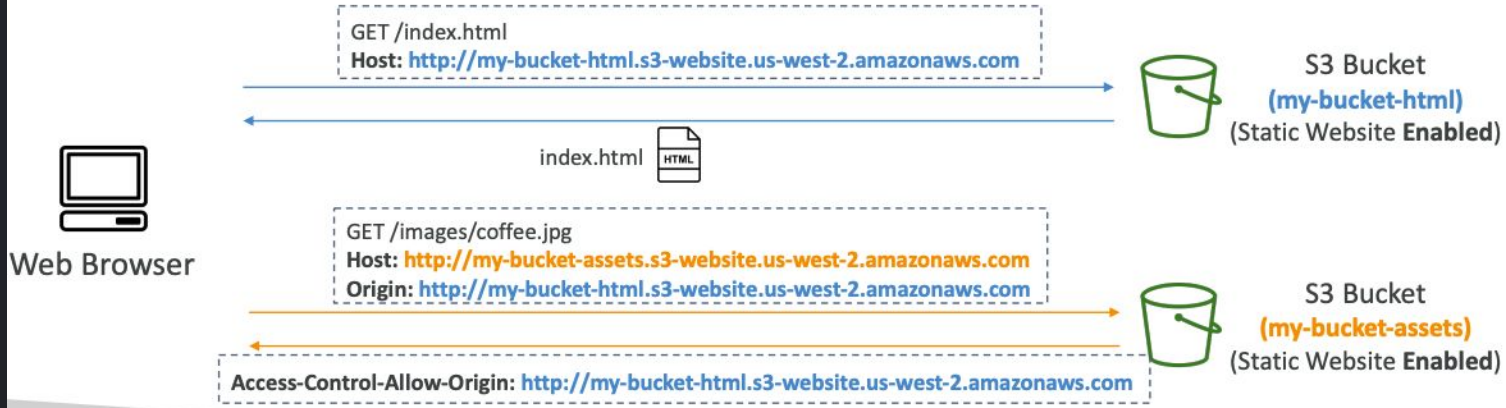
- Note: Bucket Policies are evaluated before "Default Encryption"

What is CORS?

- Cross-Origin Resource Sharing (CORS)
- Origin = scheme (protocol) + host (domain) + port
  - example: https://www.example.com (implied port is 443 for HTTPS, 80 for HTTP)
- **Web Browser** based mechanism to allow requests to other origins while visiting the main origin
- Same origin: http://example.com/app1 & http://example.com/app2
- Different origins: http://www.example.com & http://other.example.com
- The requests won't be fulfilled unless the other origin allows for the requests, using **CORS Headers** (example: **Access-Control-Allow-Origin**)

Amazon S3 – CORS

- If a client makes a cross-origin request on our S3 bucket, we need to enable the correct CORS headers
- It's a popular exam question
- You can allow for a specific origin or for * (all origins)



Amazon S3 – MFA Delete

- MFA (Multi-Factor Authentication) – force users to generate a code on a device (usually a mobile phone or hardware) before doing important operations on S3
- MFA will be required to:
  - Permanently delete an object version
  - Suspend Versioning on the bucket
- MFA won't be required to:
  - Enable Versioning
  - List deleted versions
- To use MFA Delete, **Versioning must be enabled** on the bucket
- Only the bucket owner (root account) can enable/disable MFA Delete

Google Authenticator

MFA Hardware Device

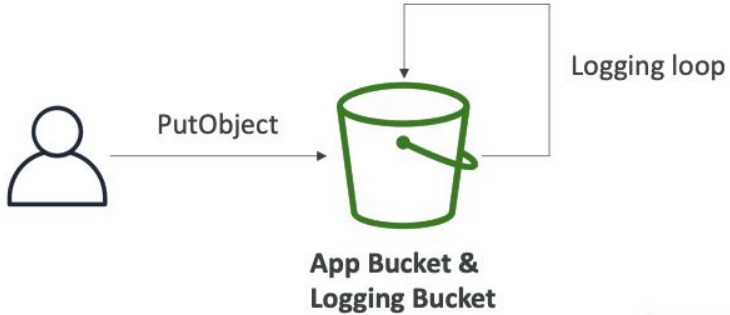
S3 Access Logs

- 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…
- The target logging bucket must be in the same AWS region

- The log format is at: https://docs.aws.amazon.com/AmazonS3/latest/dev/LogFormat.html

S3 Access Logs: Warning

- Do not set your logging bucket to be the monitored bucket
- It will create a logging loop, and your bucket will grow exponentially

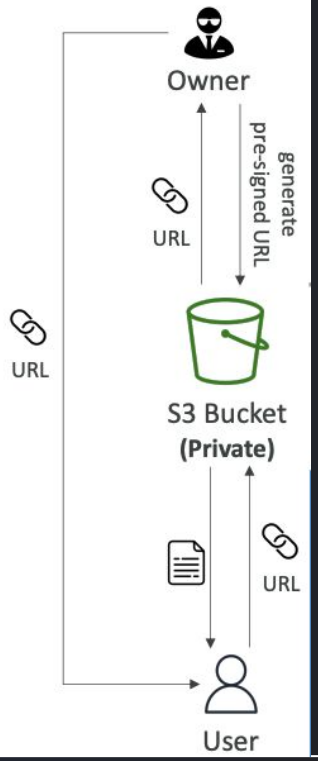


Do not try this at home ☺

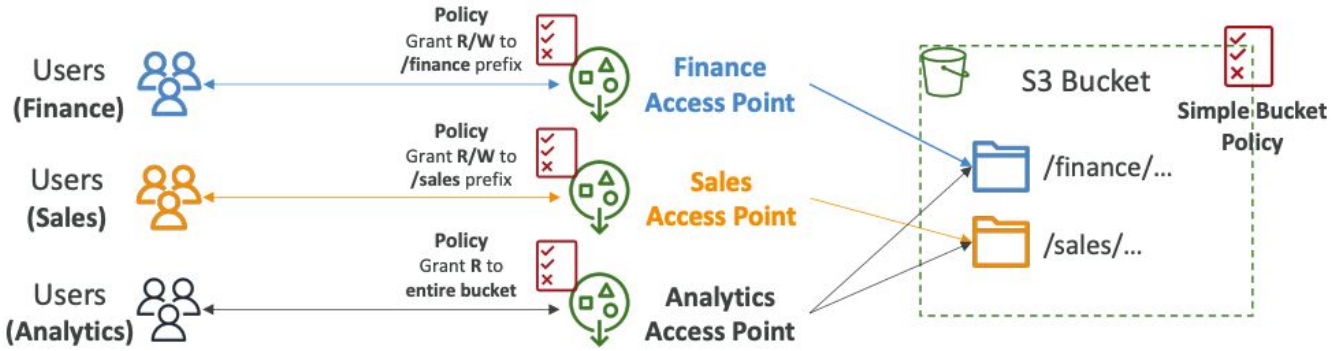
Amazon S3 – Pre-Signed URLs

- Generate pre-signed URLs using the **S3 Console, AWS CLI or SDK**
- **URL Expiration**
  - **S3 Console** – 1 min up to 720 mins (12 hours)
  - **AWS CLI** – configure expiration with *–expires-in* parameter in seconds (default 3600 secs, max. 604800 secs ~ 168 hours)
- Users given a pre-signed URL inherit the permissions of the user that generated the URL for GET / PUT

- Examples:
  - Allow only logged-in users to download a premium video from your S3 bucket
  - Allow an ever-changing list of users to download files by generating URLs dynamically
  - Allow temporarily a user to upload a file to a precise location in your S3 bucket



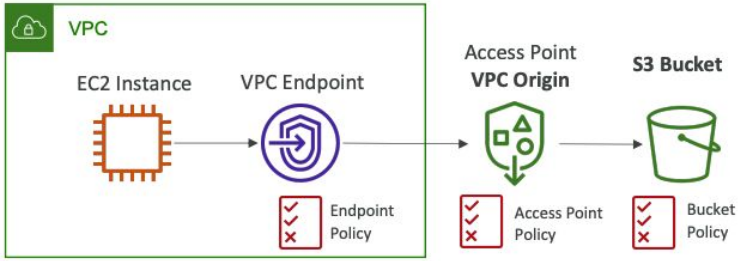
S3 – Access Points



- Access Points simplify security management for S3 Buckets
- Each Access Point has:
  - its own DNS name (Internet Origin or VPC Origin)
  - an access point policy (similar to bucket policy) – manage security at scale

S3 – Access Points – VPC Origin

- We can define the access point to be accessible only from within the VPC
- You must create a VPC Endpoint to access the Access Point (Gateway or Interface Endpoint)
- The VPC Endpoint Policy must allow access to the target bucket and Access Point




```
{
    "Version": "2012-10-17",
    "Statement": [
        {
            "Principal": "*",
            "Action": [
                "s3:GetObject"
            ],
            "Effect": "Allow",
            "Resource": [
                "arn:aws:s3:::awsexamplebucket1/*",
                "arn:aws:s3:us-west-2:123456789012:accesspoint/example-vpc-ap/object/*"
            ]
        }
    ]
}
```

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Storage extras

AWS Snowball

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AWS Snow family

AWS Snowball

- 80-TB storage capacity
- 10GE networking
- Data encryption end-to-end
- Rugged 8.5-G impact case
- Rain and dust-resistant

AWS Snowball Edge

- 100-TB storage capacity
- 10/25/40 GE networking
- Data encryption end-to-end
- Rugged 8.5-G impact case
- Rain and dust resistant
- AWS Greengrass support for local compute, messaging, and caching
- EC2/AMI support for edge compute New

AWS Snowmobile

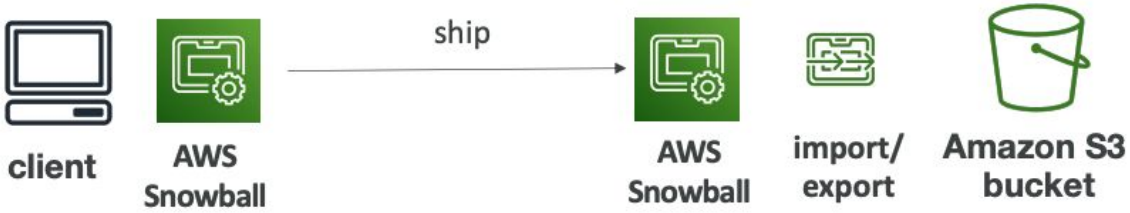
- Exabyte-scale storage in a 45-ft container
- Data encryption end-to-end
- Dedicated security personnel
- GPS tracking, alarm monitoring, 24/7 surveillance, and optional additional security

aws SUMMIT

Diagrams

- Direct upload to S3:

- With Snow Family:



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 or 28TB NVMe capacity for block volume and S3 compatible object storage
- Use cases: large data cloud migrations, DC decommission, disaster recovery

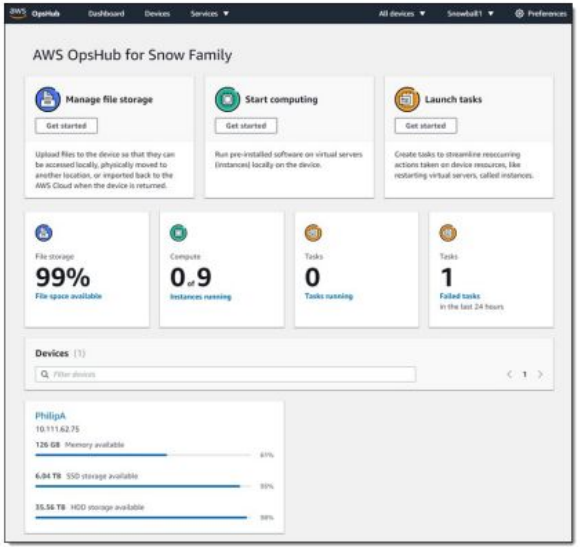
AWS Snowcone & Snowcone SSD

- 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
- **Snowcone** – 8 TB of HDD Storage
- **Snowcone SSD** – 14 TB of SSD 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 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))



https://aws.amazon.com/blogs/aws/aws-snowball-edge-update/

Amazon FSx – Overview

- Launch 3rd party high-performance file systems on AWS
- Fully managed service

FSx for Lustre

FSx for
NetApp ONTAP

FSx for Windows
File Server

FSx for
OpenZFS

Amazon FSx for Windows (File Server)

- **FSx for Windows** is a fully managed **Windows** file system share drive
- Supports SMB protocol & Windows NTFS
- Microsoft Active Directory integration, ACLs, user quotas
- **Can be mounted on Linux EC2 instances**
- Supports **Microsoft's Distributed File System (DFS) Namespaces** (group files across multiple FS)

- Scale up to 10s of GB/s, millions of IOPS, 100s PB of data
- Storage Options:
  - **SSD** – latency sensitive workloads (databases, media processing, data analytics, …)
  - **HDD** – broad spectrum of workloads (home directory, CMS, …)
- Can be accessed from your on-premises infrastructure (VPN or Direct Connect)
- Can be configured to be Multi-AZ (high availability)
- Data is backed-up daily to S3

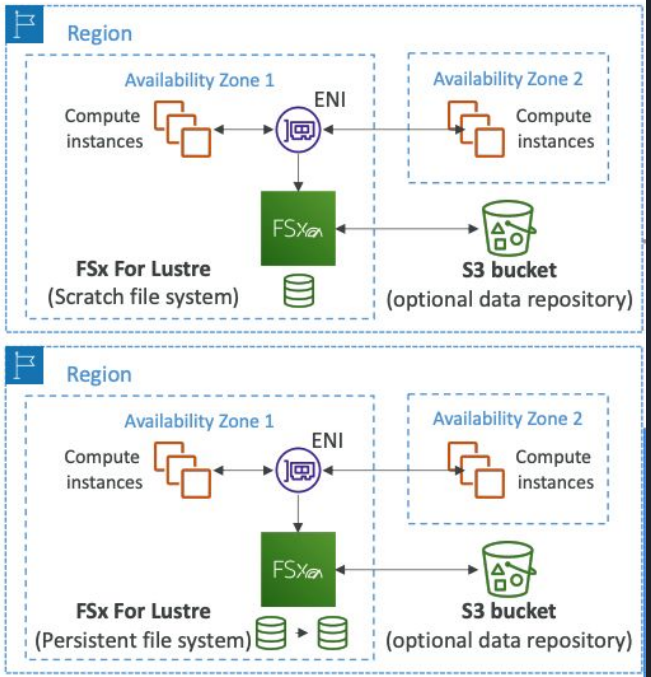
Amazon FSx for Lustre

- Lustre is a type of parallel distributed file system, for large-scale computing
- The name Lustre is derived from "Linux" and "cluster

- Machine Learning, **High Performance Computing (HPC)**
- Video Processing, Financial Modeling, Electronic Design Automation
- Scales up to 100s GB/s, millions of IOPS, sub-ms latencies
- Storage Options:
  - **SSD** – low-latency, IOPS intensive workloads, small & random file operations
  - **HDD** – throughput-intensive workloads, large & sequential file operations
- **Seamless integration with S3**
  - Can "read S3" as a file system (through FSx)
  - Can write the output of the computations back to S3 (through FSx)
- **Can be used from on-premises servers (VPN or Direct Connect)**

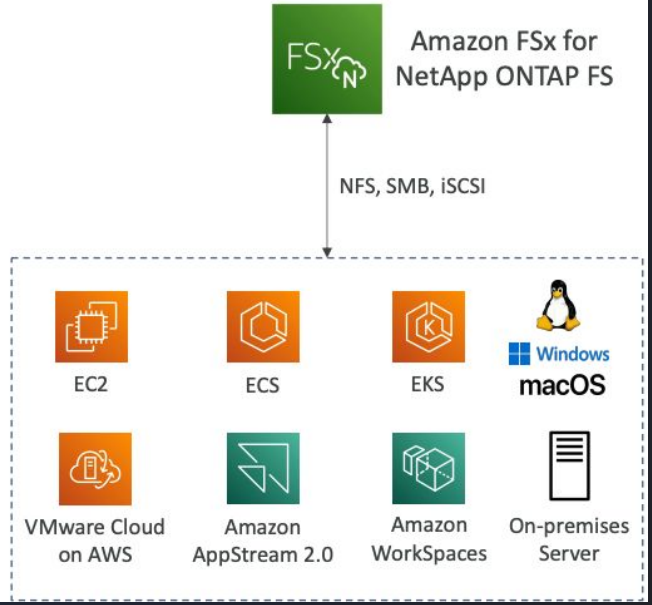
FSx Lustre - File System Deployment Options

- Scratch File System
  - Temporary storage
  - Data is not replicated (doesn't persist if file server fails)
  - High burst (6x faster, 200MBps per TiB)
  - Usage: short-term processing, optimize costs
- Persistent File System
  - Long-term storage
  - Data is replicated within same AZ
  - Replace failed files within minutes
  - Usage: long-term processing, sensitive data



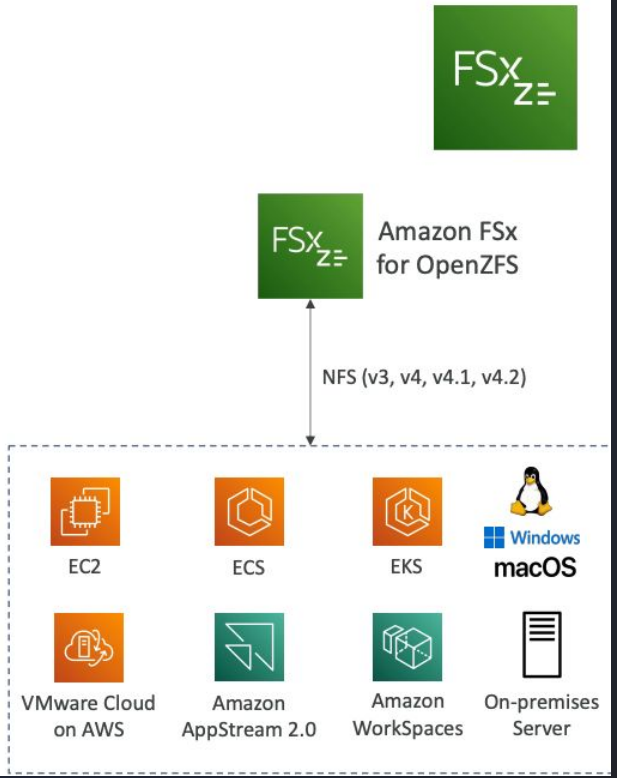
Amazon FSx for NetApp ONTAP

- Managed NetApp ONTAP on AWS
- File System compatible with NFS, SMB, iSCSI protocol
- Move workloads running on ONTAP or NAS to AWS
- Works with:
  - Linux
  - Windows
  - MacOS
  - VMware Cloud on AWS
  - Amazon Workspaces & AppStream 2.0
  - Amazon EC2, ECS and EKS
- Storage shrinks or grows automatically
- Snapshots, replication, low-cost, compression and data de-duplication
- Point-in-time instantaneous cloning (helpful for testing new workloads)



Amazon FSx for OpenZFS

- Managed OpenZFS file system on AWS
- File System compatible with NFS (v3, v4, v4.1, v4.2)
- Move workloads running on ZFS to AWS
- Works with:
  - Linux
  - Windows
  - MacOS
  - VMware Cloud on AWS
  - Amazon Workspaces & AppStream 2.0
  - Amazon EC2, ECS and EKS
- Up to 1,000,000 IOPS with < 0.5ms latency
- Snapshots, compression and low-cost
- Point-in-time instantaneous cloning (helpful for testing new workloads)



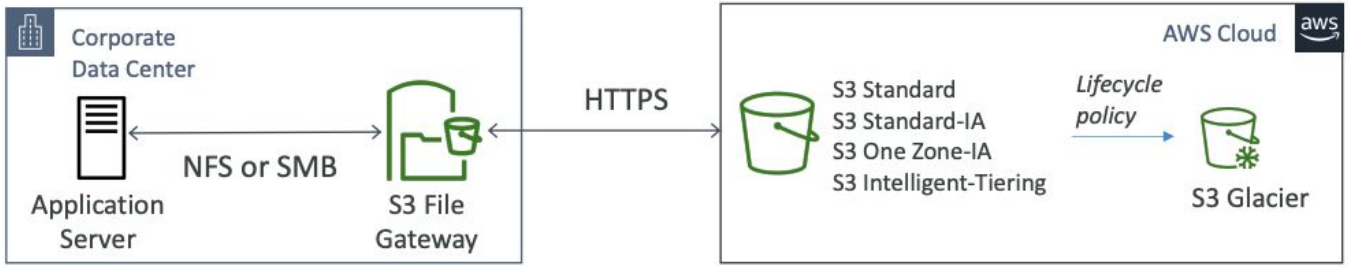
AWS Storage Cloud Native Options

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

Amazon S3 File Gateway

- Configured S3 buckets are accessible using the NFS and SMB protocol
- **Most recently used data is cached in the file gateway**
- Supports S3 Standard, S3 Standard IA, S3 One Zone A, S3 Intelligent Tiering
- **Transition to S3 Glacier using a Lifecycle Policy**
- Bucket access using IAM roles for each File Gateway
- SMB Protocol has integration with Active Directory (AD) for user authentication



Amazon S3 File Gateway

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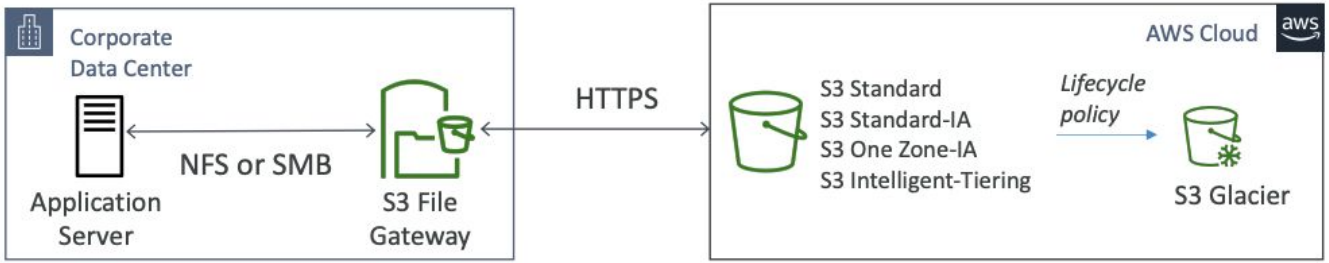
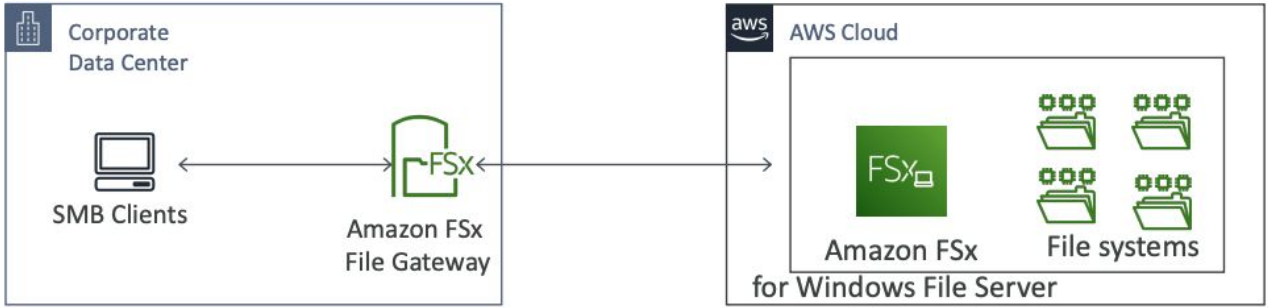


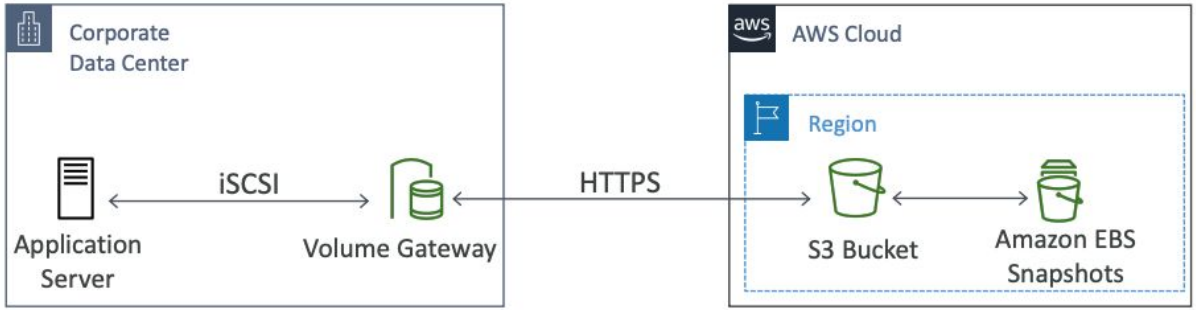
Amazon FSx File Gateway

- Native access to Amazon FSx for Windows File Server
- Local cache for frequently accessed data
- Windows native compatibility (SMB, NTFS, Active Directory...)
- Useful for group file shares and home directories



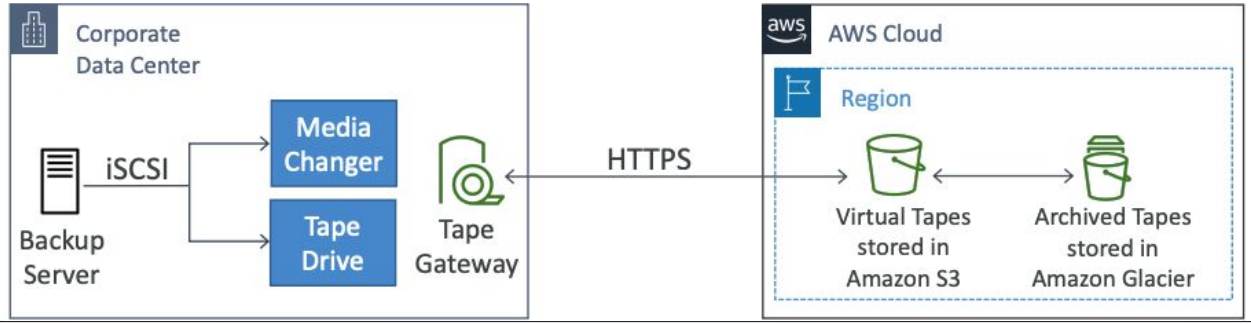
Volume Gateway

- Block storage using iSCSI protocol backed by S3
- Backed by EBS snapshots which can help restore on-premises volumes!
- **Cached volumes:** low latency access to most recent data
- **Stored volumes:** entire dataset is on premise, scheduled backups to S3



Tape Gateway

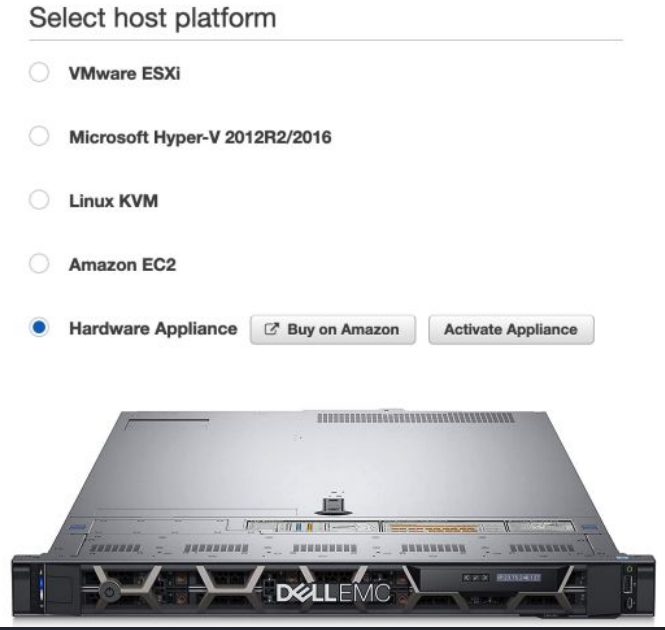
- Some companies have backup processes using physical tapes (!)
- With Tape Gateway, companies use the same processes but, in the cloud
- Virtual Tape Library (VTL) backed by Amazon S3 and Glacier
- Back up data using existing tape-based processes (and iSCSI interface)
- Works with leading backup software vendors



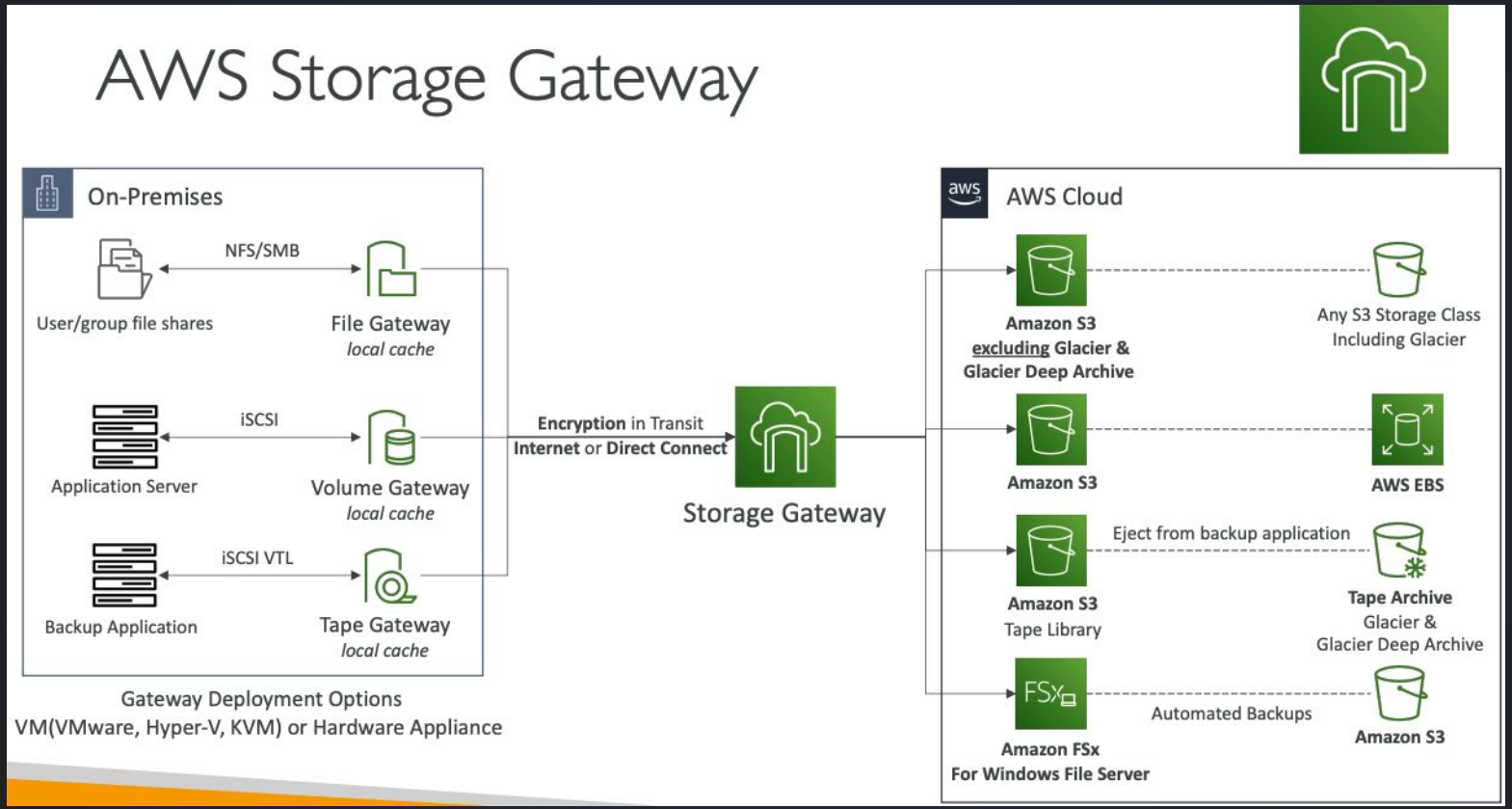
Storage Gateway – Hardware appliance

- Using Storage Gateway means you need on-premises virtualization
- Otherwise, you can use a **Storage Gateway Hardware Appliance**
- You can buy it on amazon.com

- Works with File Gateway, Volume Gateway, Tape Gateway
- Has the required CPU, memory, network, SSD cache resources
- Helpful for daily NFS backups in small data centers



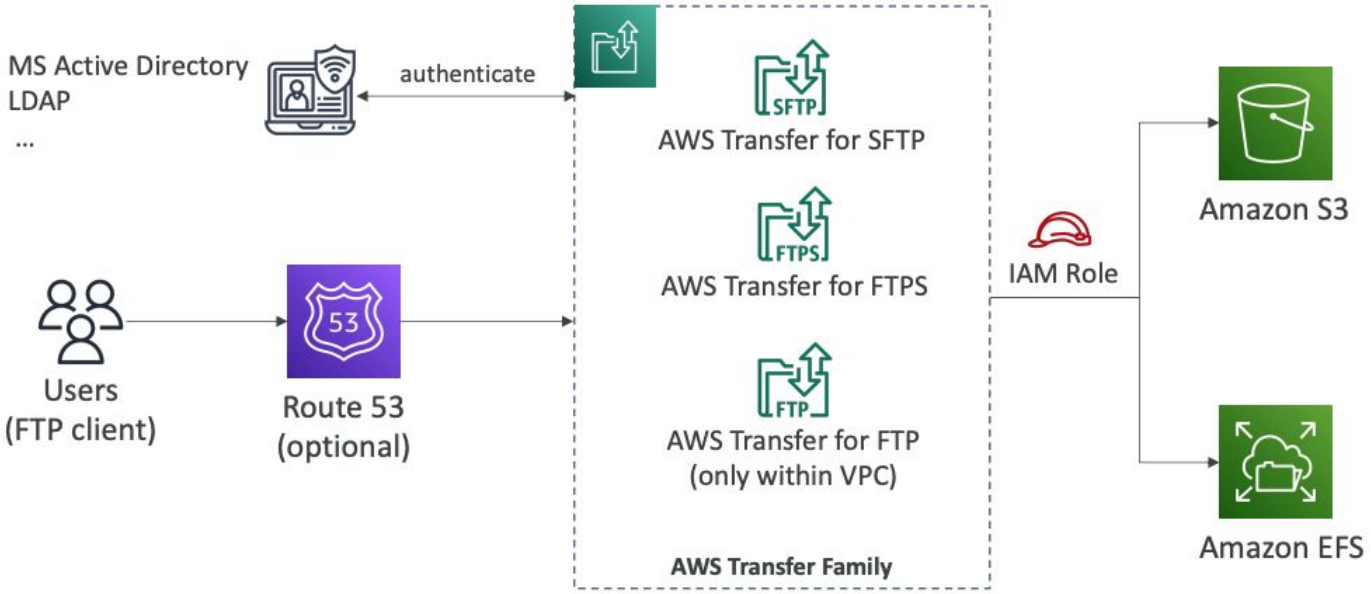
AWS Storage Gateway



AWS Transfer Family

- A fully-managed service for file transfers into and out of Amazon S3 or Amazon EFS using the FTP protocol
- Supported Protocols
  - **AWS Transfer for FTP** (File Transfer Protocol (FTP))
  - **AWS Transfer for FTPS** (File Transfer Protocol over SSL (FTPS))
  - **AWS Transfer for SFTP** (Secure File Transfer Protocol (SFTP))
- Managed infrastructure, Scalable, Reliable, Highly Available (multi-AZ)
- Pay per provisioned endpoint per hour + data transfers in GB
- Store and manage users' credentials within the service
- Integrate with existing authentication systems (Microsoft Active Directory, LDAP, Okta, Amazon Cognito, custom)
- Usage: sharing files, public datasets, CRM, ERP, …

AWS Transfer Family

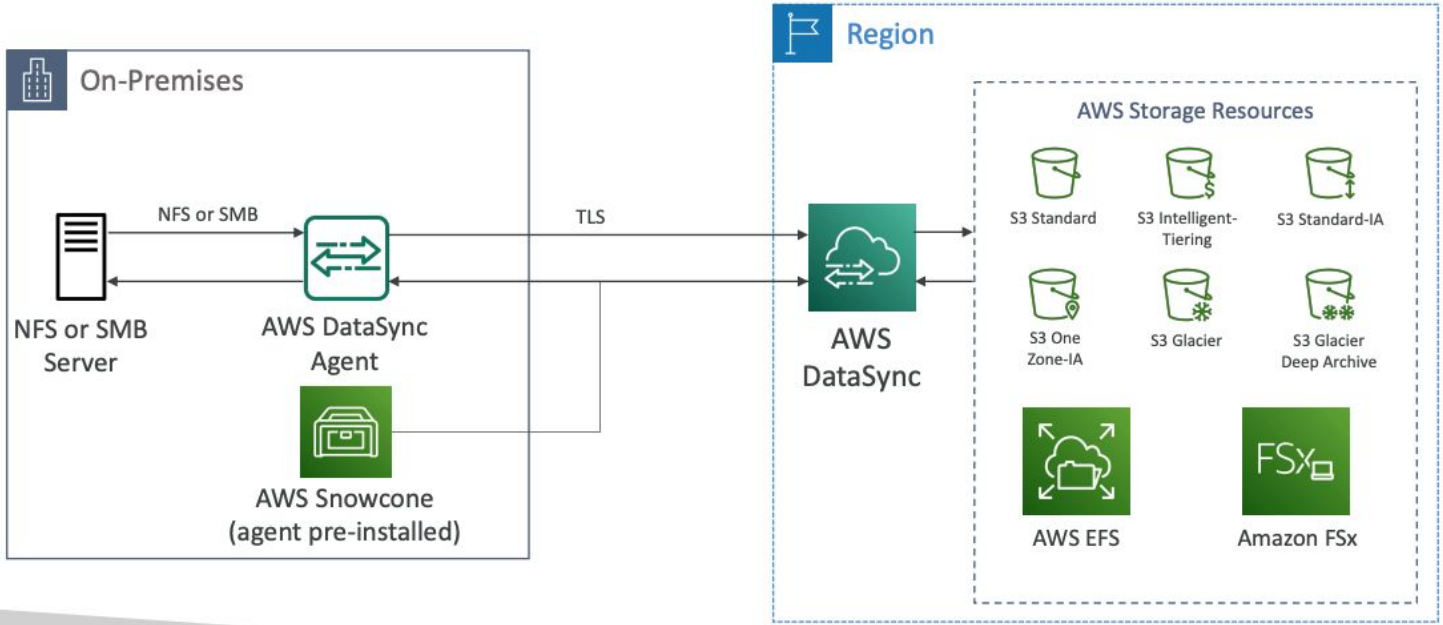


AWS DataSync

- 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

https://tutorialsdojo.com/aws-datasync-vs-storage-gateway/

AWS DataSync
NFS / SMB to AWS (S3, EFS, FSx…)



AWS DataSync
Transfer between AWS storage services

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

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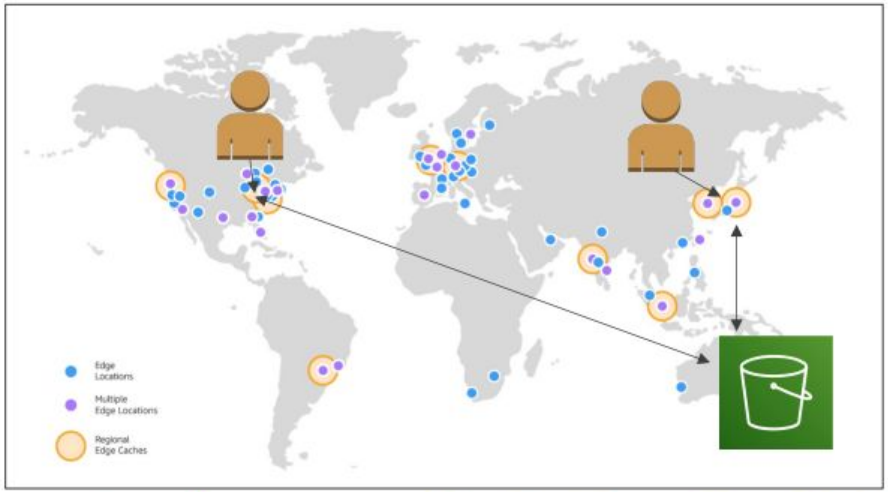
CloudFront

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

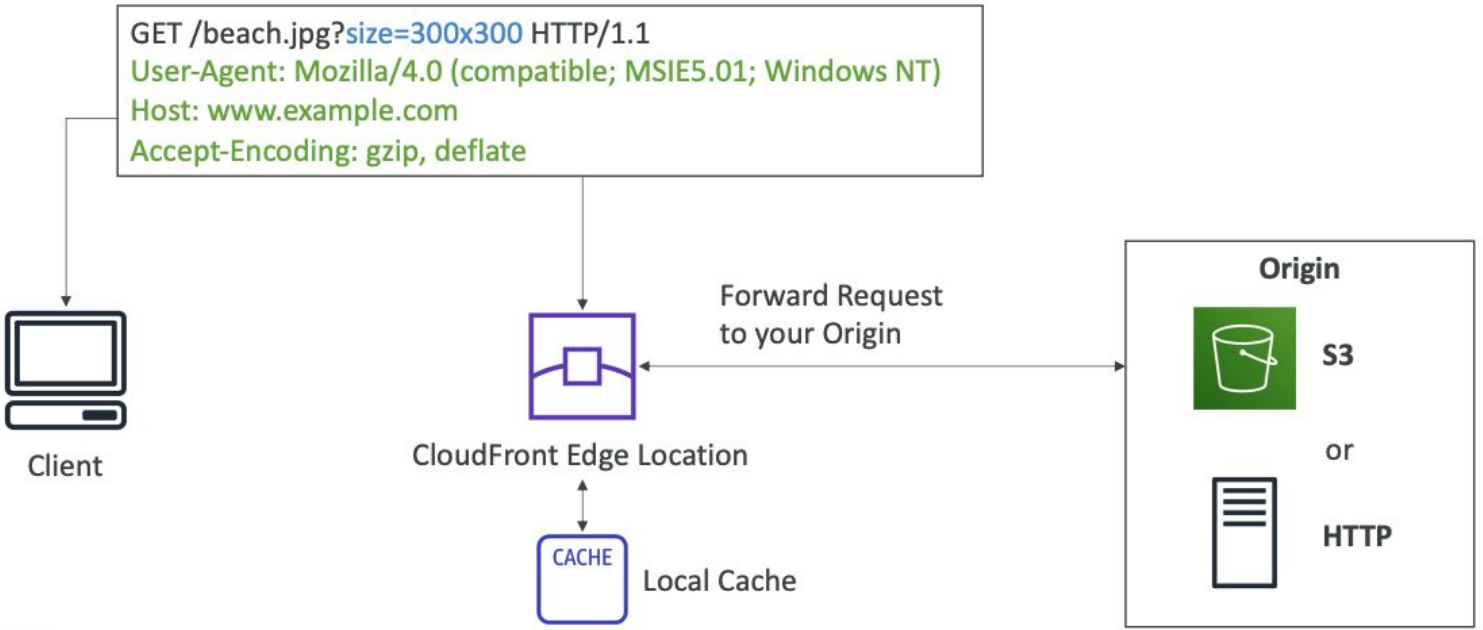


Source: https://aws.amazon.com/cloudfront/features/?nc=sn&loc=2

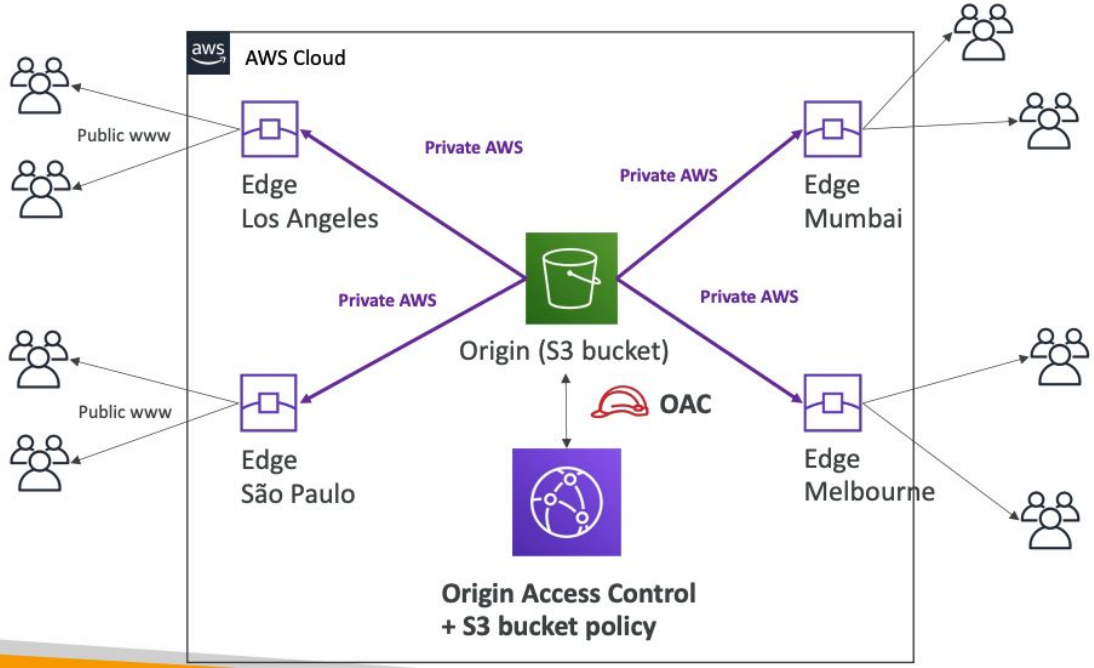
CloudFront – Origins

- S3 bucket
  - For distributing files and caching them at the edge
  - Enhanced security with CloudFront **Origin Access Control (OAC)**
  - OAC is replacing 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 at a high level



CloudFront – S3 as an Origin

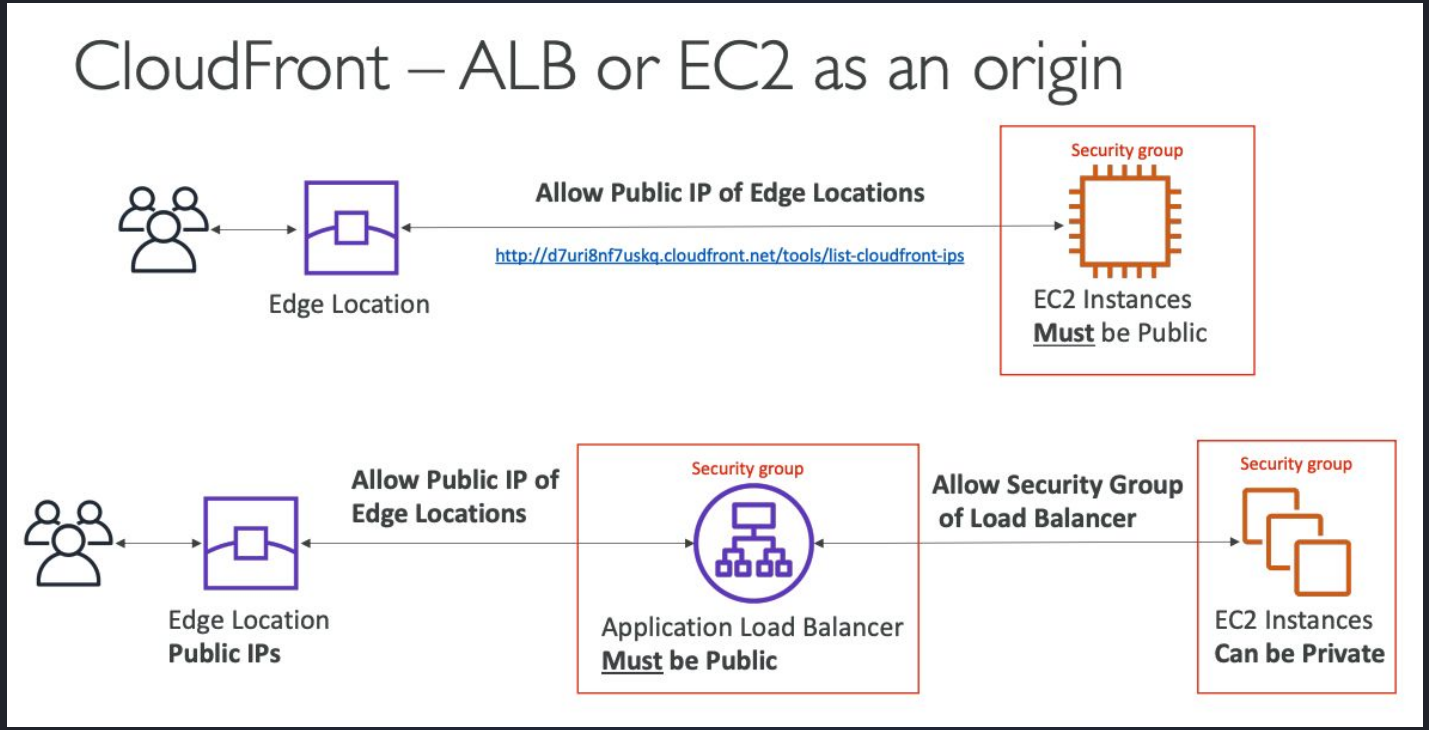


FIBO CLOUD EDUCATION

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



https://d7uri8nf7uskq.cloudfront.net/tools/list-cloudfront-ips

CloudFront Geo Restriction

- You can restrict who can access your distribution
  - **Allowlist:** Allow your users to access your content only if they're in one of the countries on a list of approved countries.
  - **Blocklist:** Prevent your users from accessing your content if they're in one of the countries on a list of banned countries.
- The "country" is determined using a 3rd party Geo-IP database
- Use case: Copyright Laws to control access to content

CloudFront - Pricing

- CloudFront Edge locations are all around the world
- The cost of data out per edge location varies

Per Month	United States, Mexico, & Canada	Europe & Israel	South Africa, Kenya, & Middle East	South America	Japan	Australia & New Zealand	Hong Kong, Philippines, Singapore, South Korea, Taiwan, & Thailand	India
First 10TB	$0.085	$0.085	$0.110	$0.110	$0.114	$0.114	$0.140	$0.170
Next 40TB	$0.080	$0.080	$0.105	$0.105	$0.089	$0.098	$0.135	$0.130
Next 100TB	$0.060	$0.060	$0.090	$0.090	$0.086	$0.094	$0.120	$0.110
Next 350TB	$0.040	$0.040	$0.080	$0.080	$0.084	$0.092	$0.100	$0.100
Next 524TB	$0.030	$0.030	$0.060	$0.060	$0.080	$0.090	$0.080	$0.100
Next 4PB	$0.025	$0.025	$0.050	$0.050	$0.070	$0.085	$0.070	$0.100
Over 5PB	$0.020	$0.020	$0.040	$0.040	$0.060	$0.080	$0.060	$0.100

CloudFront – Price Classes

- You can reduce the number of edge locations for **cost reduction**
- Three price classes:
  1. Price Class All: all regions – best performance
  2. Price Class 200: most regions, but excludes the most expensive regions
  3. Price Class 100: only the least expensive regions

Edge Locations Included Within	United States, Mexico, & Canada	Europe & Israel	South Africa, Kenya, & Middle East	South America	Japan	Australia & New Zealand	Hong Kong, Philippines, Singapore, South Korea, Taiwan, & Thailand	India
Price Class All	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Price Class 200	Yes	Yes	Yes	x	Yes	x	Yes	Yes
Price Class 100	Yes	Yes	x	x	x	x	x	x

CloudFront – Cache Invalidations

- In case you update the back-end origin, CloudFront doesn't know about it and will only get the refreshed content after the TTL has expired
- However, you can force an entire or partial cache refresh (thus bypassing the TTL) by performing a **CloudFront Invalidation**
- You can invalidate all files (*) or a special path (/images/*)