

**CS 4037**  
**Introduction to Cloud Computing**  
**Lecture 27**

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# AWS Storage

# Lecture's Agenda

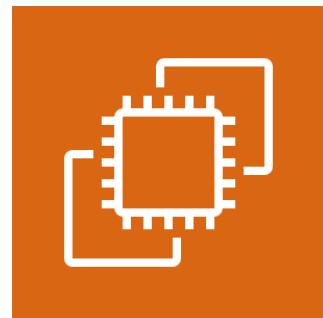
- **Amazon Elastic Block Store (Amazon EBS)**
- Amazon Simple Storage Service (S3)
- Amazon Elastic File System (Amazon EFS)
- Amazon Simple Storage Service Glacier



# Core AWS services



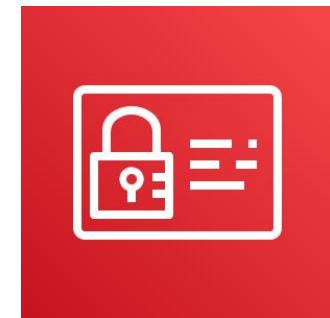
**Amazon Virtual  
Private Cloud  
(Amazon VPC)**



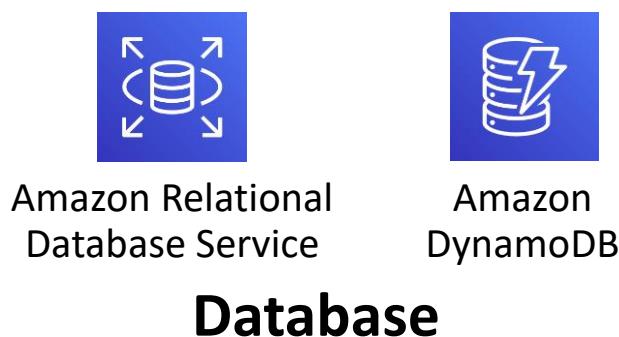
**Amazon Elastic  
Compute Cloud  
(Amazon EC2)**



**Storage**



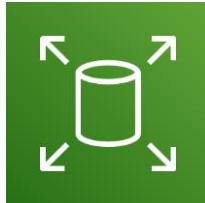
**AWS Identity and Access  
Management (IAM)**



**Database**

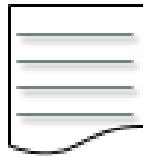
# Amazon Elastic Block Store (Amazon EBS)

- Provides **persistent** (non-volatile) block storage volume for use with EC2 instances
- Each EBS volume is **replicated** within its Availability Zone
- Can be backed up to S3 storage through **snapshots**

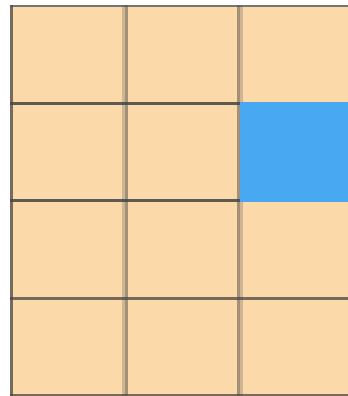


Amazon Elastic Block Store  
(Amazon EBS)

# AWS Storage Options: Block Storage versus Object Storage

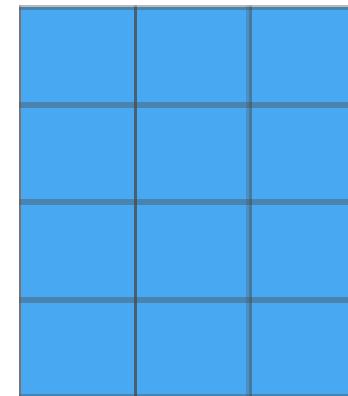


What if you want to change **one character** in a 1-GB file?



**Block storage**

Change one block (piece of the file)  
that contains the character



**Object storage**

Entire file must be updated

# Amazon EBS Common Uses

- EC2 Boot volumes & EC2 additional volumes
- Data storage with a file system
- Database hosts
- Enterprise applications

# Amazon EBS Volume Types

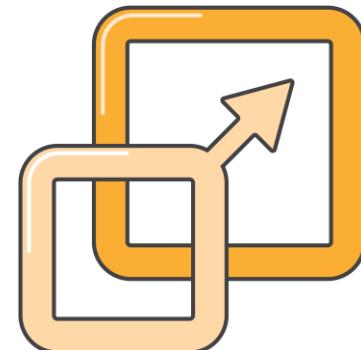
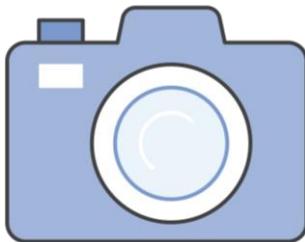
	Solid State Drives (SSD)		Hard Disk Drives (HDD)	
	General Purpose	Provisioned IOPS	Throughput-Optimized	Cold
Maximum Volume Size	16 TiB	16 TiB	16 TiB	16 TiB
Maximum IOPS/Volume	16,000	64,000	500	250
Maximum Throughput/Volume	250 MiB/s	1,000 MiB/s	500 MiB/s	250 MiB/s

# Amazon EBS Volume Type Use Cases

Solid State Drives (SSD)		Hard Disk Drives (HDD)	
General Purpose	Provisioned IOPS	Throughput-Optimized	Cold
<ul style="list-style-type: none"><li>This type is recommended for most workloads</li><li>System boot volumes</li><li>Virtual desktops</li><li>Low-latency interactive applications</li><li>Development and test environments</li></ul>	<ul style="list-style-type: none"><li>Critical business applications that require sustained IOPS performance, or more than 16,000 IOPS or 250 MiB/second of throughput per volume</li><li>Large database workloads</li></ul>	<ul style="list-style-type: none"><li>Streaming workloads that require consistent, fast throughput at a low price</li><li>Big data</li><li>Data warehouses</li><li>Log processing</li></ul>	<ul style="list-style-type: none"><li>Throughput-oriented storage for large volumes of data that is infrequently accessed</li><li>Scenarios where the lowest storage cost is important</li><li>It cannot be a boot volume</li></ul>

# Amazon EBS Features

- **Snapshots**
  - Point-in-time snapshots
  - Recreate a new volume at any time
- **Encryption**
  - Encrypted Amazon EBS volumes
  - No additional cost
- **Elasticity**
  - Increase capacity
  - Change to different types



# Amazon EBS Demo



## Set up demo

Amazon Elastic Block Store (EBS)



# Lab 4: Working with Amazon EBS

## Lab Scenario:

This lab is designed to show you how to create an Amazon **EBS volume**. After you create the volume, you will attach the volume to an Amazon EC2 instance, configure the instance to use a virtual disk, create a snapshot and then restore from the snapshot.



# Lab 4: Working with Amazon EBS (Cont.)

## Lab Tasks:

- Task 1 – Create a New EBS Volume
- Task 2 – Attach the Volume to an Instance
- Task 3 – Connect to the Amazon EC2 Instance
- Task 4 – Create and Configure the File System
- Task 5 – Create an Amazon EBS Snapshot
- Task 6 – Restore the Amazon EBS Snapshot
  - Create a Volume Using the Snapshot
  - Mount the Restored Volume

# Amazon EBS – Key Points

- Persistent and customizable **block storage** for Amazon EC2
- HDD and SSD types
- Replicated in the same Availability Zone
- Easy and transparent **encryption**
- Elastic volumes
  - Instance don't required to power-off during resizing of volume
- Back up by using **snapshots**

# Lecture's Agenda

- Amazon Elastic Block Store (Amazon EBS)
- **Amazon Simple Storage Service (S3)**
- Amazon Elastic File System (Amazon EFS)
- Amazon Simple Storage Service Glacier



# Amazon Simple Storage Service (Amazon S3)

- **S3 is managed object-level storage**
  - If user want to change a part of a file, user must make the change and then re-upload the entire modified file
- **Data is stored as objects in buckets**
- **Virtually unlimited storage**
  - Single object is limited to 5 TB
- **Designed for 11 9s of durability**
- **Granular access to bucket and objects**
  - Bucket names are **universal** and must be **unique** worldwide across all existing buckets



Amazon S3

# Amazon S3 (Cont.)

- Amazon S3 includes **event notifications**
  - Enables to set up **automatic notifications** when certain events occur
    - ✓ Example: An object is uploaded to a bucket or deleted from a bucket
  - Notifications can be sent to customer
  - Notifications can be used to trigger other processes like Lambda functions
- You get **fine-grained control** over who can access S3 data
  - IAM policies
  - S3 bucket policies
  - Per-object access control lists
- Amazon S3 is **accessible** through AWS Management Console, AWS CLI, AWS SDK, or third party tools

# S3 Storage Classes

## Amazon S3 Standard:

- Designed for frequently accessed data
- Delivers low latency and high throughput
- Appropriate for cloud applications, dynamic websites, content distribution, mobile and gaming applications, and big data analytics

# S3 Storage Classes (Cont.)

## Amazon S3 Standard-Infrequent Access:

- Used for data that is accessed less frequently, but requires rapid access when needed
- Designed to provide S3 Standard, with a low per-GB storage price and per-GB retrieval fee
- Good for long-term storage and backups, and as a data store for disaster recovery files

# S3 Storage Classes (Cont.)

## Amazon S3 Intelligent-Tiering

- Designed to optimize costs by automatically moving data to the most **cost-effective access tier**, without performance impact or operational overhead
- Monitors access patterns of the objects and moves the objects that have not been accessed for 30 consecutive days to the **infrequent access tier**
  - If an object in the infrequent access tier is accessed, it is automatically moved back to the frequent access tier

# S3 Storage Classes (Cont.)

## Amazon S3 One Zone-Infrequent Access:

- Stores data in a single Availability Zone
  - Unlike other S3 storage classes, which store data in a minimum of three AZs
- Costs less than Amazon S3 Standard-IA
- Works well for customers who want a lower-cost option for infrequently accessed data
- Good choice for storing secondary backup copies of on-premises data or easily re-creatable data

# S3 Storage Classes (Cont.)

## Amazon S3 Glacier:

- Low-cost storage class for data archiving
- Provides three retrieval options that range from a few minutes to hours
- Customer can upload objects directly to Amazon S3 Glacier
- Customer can use S3 lifecycle policies to transfer data between any of the S3 storage classes

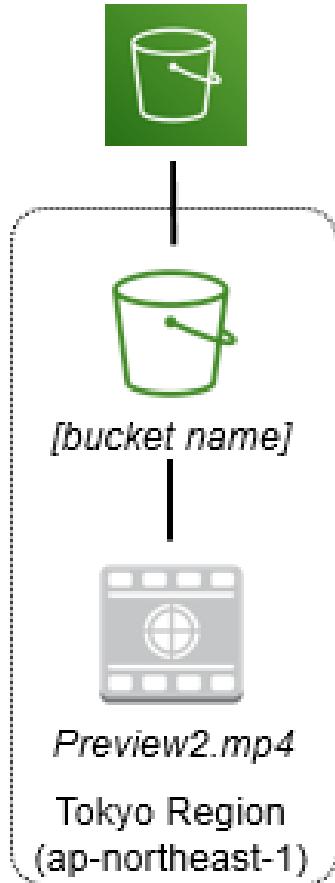
# S3 Storage Classes (Cont.)

## Amazon S3 Glacier Deep Archive:

- Lowest-cost storage class
- Supports long-term retention and digital preservation for data that might be accessed once or twice in a year
- Designed for customers in highly regulated industries
  - Example: Financial services, healthcare, and public sectors
    - ✓ Retain datasets for 7–10 years (or more) to meet regulatory compliance requirements
- All objects are replicated across at least three Availability Zones, and these objects can be restored within 12 hours

# Amazon S3 Bucket URLs (Two Styles)

Amazon S3



To upload your data:

1. Create a **bucket** in an AWS Region.
2. Upload almost any number of **objects** to the bucket.

Bucket path-style URL endpoint:

<https://s3.ap-northeast-1.amazonaws.com/bucket-name>

Region code

Bucket name

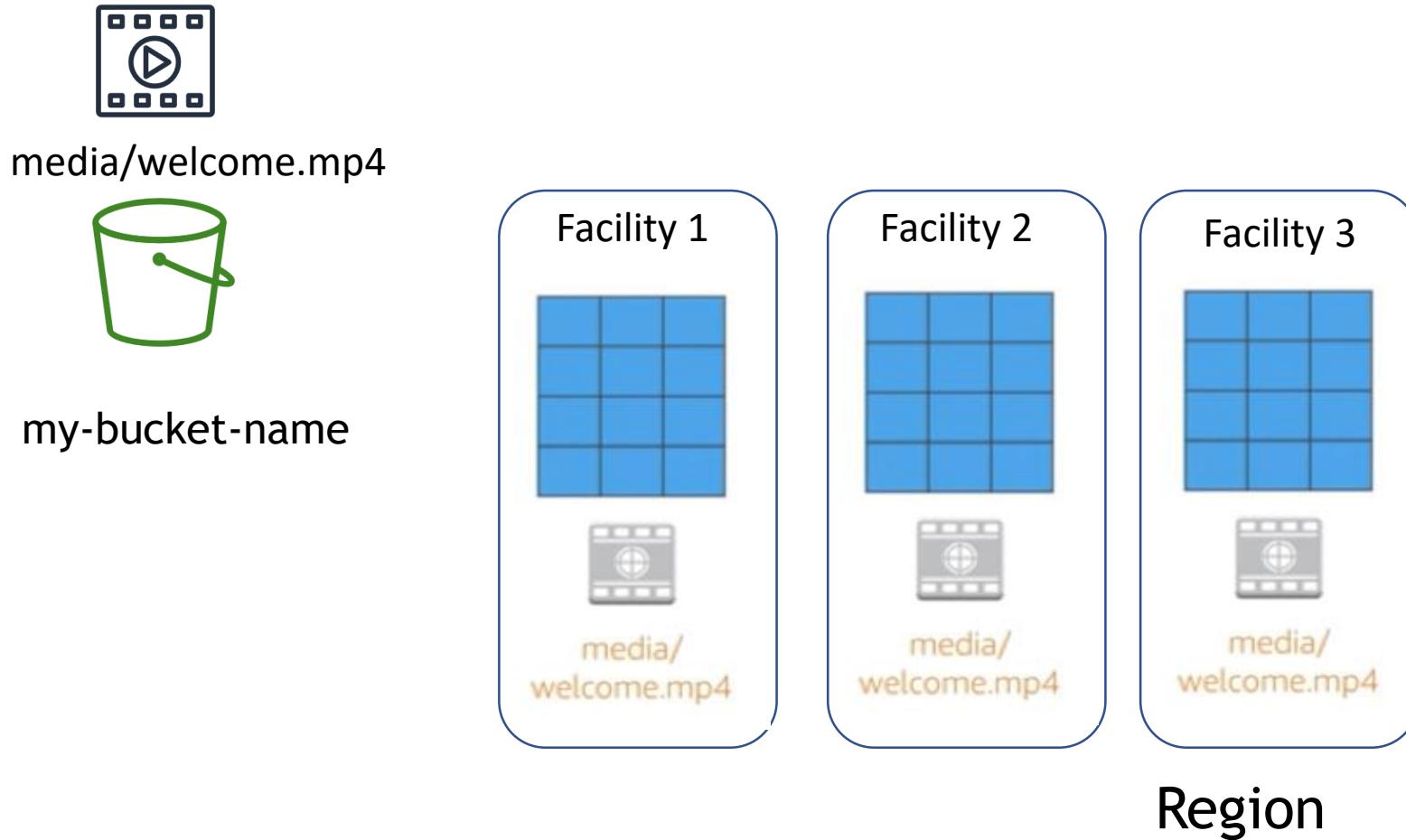
Bucket virtual hosted-style URL endpoint:

<https://bucket-name.s3-ap-northeast-1.amazonaws.com>

Bucket name

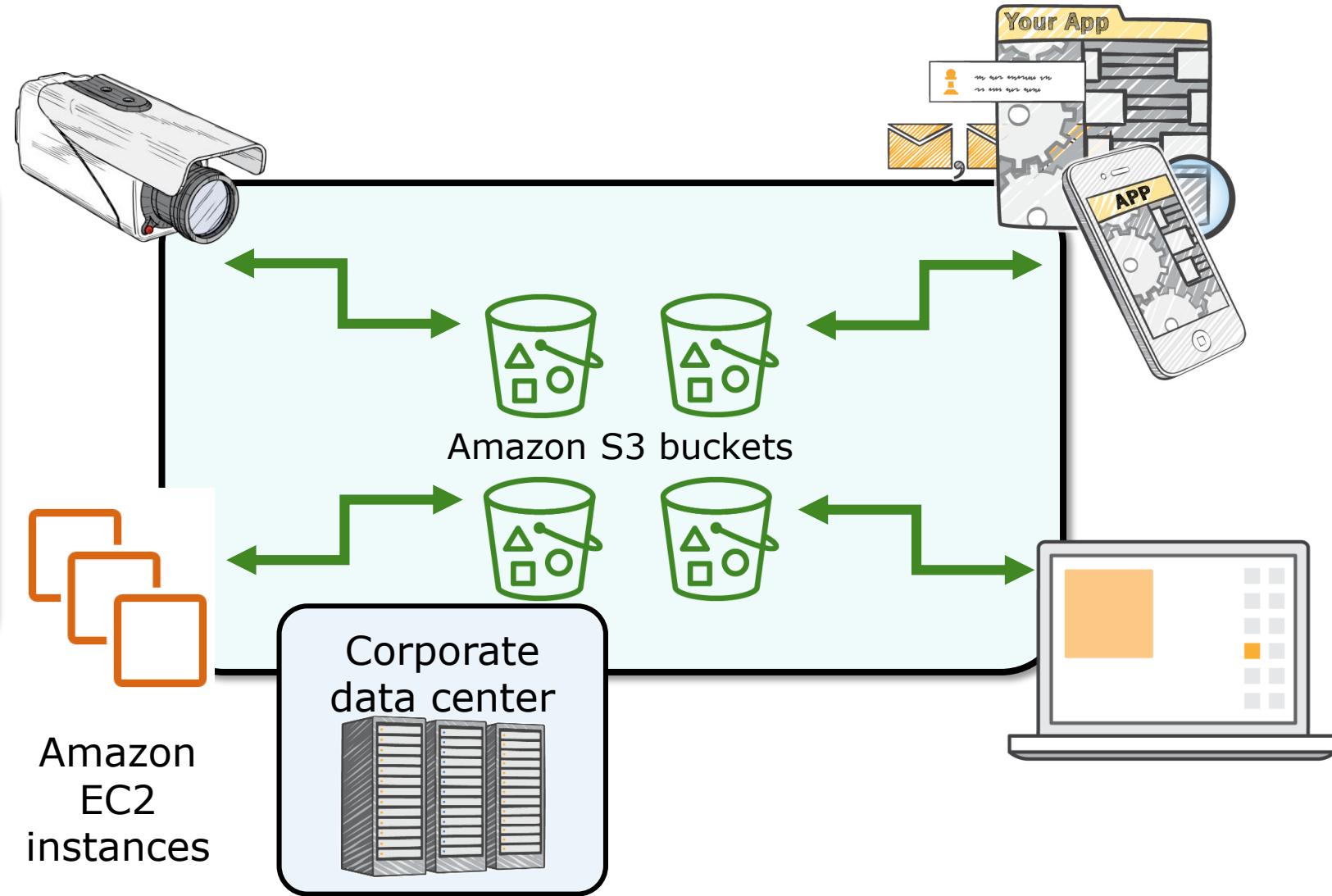
Region code

# Data is Redundantly Stored in the Region



# Amazon S3 Common Scenarios

- Backup and storage
- Application hosting
- Media hosting
- Software delivery



# Amazon S3 Pricing

- You pay for
  - GBs per month
  - Transfer OUT to other Regions
  - PUT, COPY, POST, LIST, and GET requests
- You do not pay for
  - Transfers IN to Amazon S3
  - Transfers OUT from Amazon S3 to Amazon CloudFront or Amazon EC2 in the same Region

# Amazon S3: Storage Pricing Factors

- To estimate Amazon S3 costs, consider the following:

## Storage Class Type:

- Standard storage is designed for:
  - 11 9s of durability
  - Four 9s of availability
- S3 Standard-Infrequent Access (S-IA) is designed for:
  - 11 9s of durability
  - Three 9s of availability

## Amount of Storage:

- The number and size of objects

# Amazon S3: Storage Pricing Factors (Cont.)

## Requests:

- The number and type of requests (GET, PUT, COPY)
  - Different rates for different request types

## Data Transfer

- Pricing is based on the amount of data that is transferred out of the Amazon S3 Region
  - Data transfer in is free, but you incur charges for data that is transferred out

# Amazon S3 Demo



## Set up demo

Amazon S3



# Amazon S3 – Key Points

- Amazon S3 is a **fully managed** cloud storage service
- You can **store** a virtually unlimited number of objects
- You can **access** Amazon S3 at any time from anywhere through a URL
- Amazon S3 **offers** rich security controls

# Lecture's Agenda

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- **Amazon Elastic File System (Amazon EFS)**
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# Amazon Elastic File System

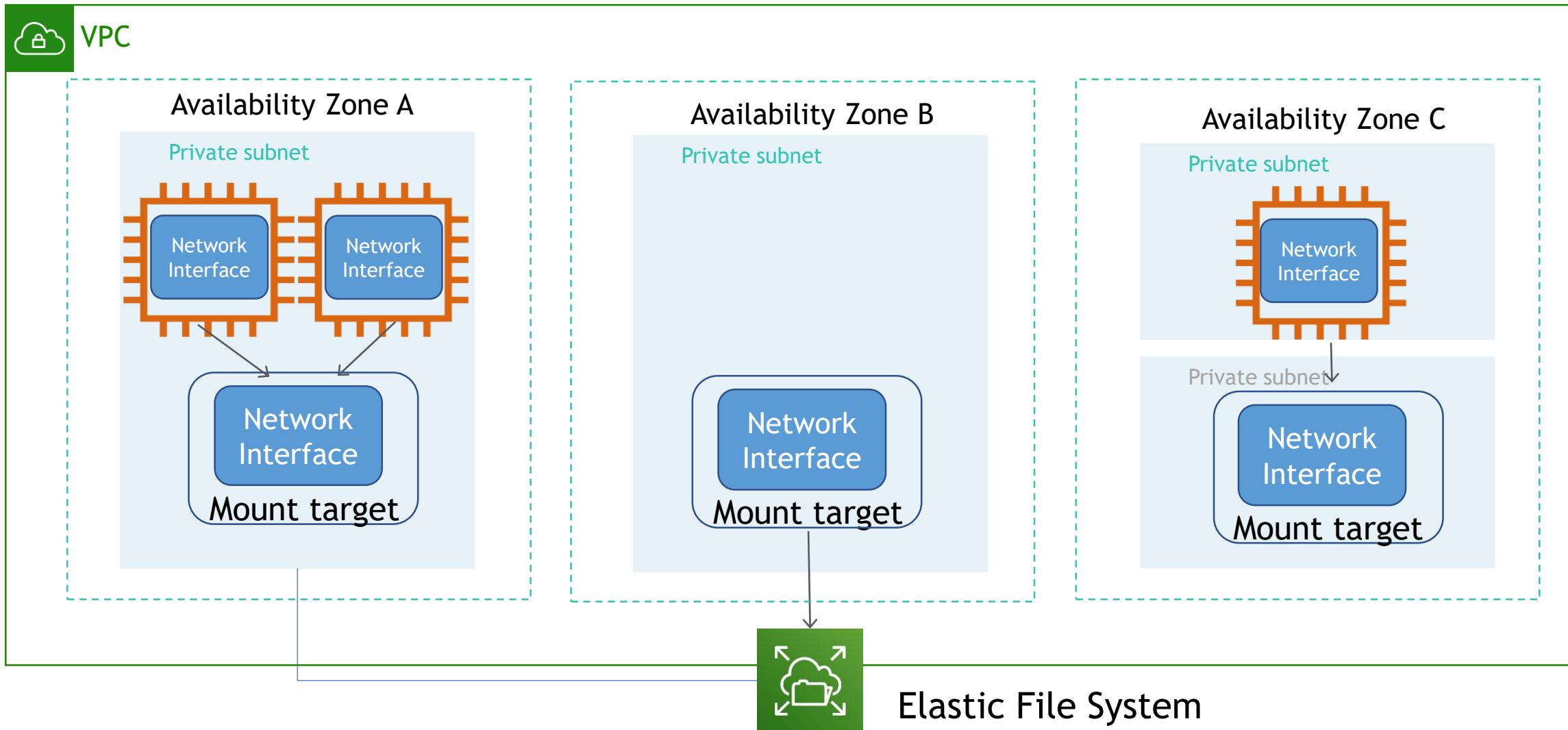
- Amazon EFS implements storage for EC2 instances that **multiple virtual machines** can access at the same time
- It is implemented as a **shared file system** that uses the Network File System (NFS) protocol



Amazon EFS

- Compatible with all **Linux-based AMIs** for Amazon EC2
- Works well for **big data analytics**, media processing workflows, content management, web serving, and home directories

# Amazon EFS Architecture



# Amazon EFS Implementation

- Create EC2 instance
- Launch EC2 instance
- Create EFS file system
- Create mount targets in the appropriate subnets
- Connect Amazon EC2 instances to the mount targets
- Verify the resources and protection of the AWS account

# Amazon EFS Resources

## File system

- Mount target
  - Subnet ID
  - Security groups
    - ✓ One or more per file system
  - Create in a VPC subnet
    - ✓ One per Availability Zone
  - Must be in the same VPC
- Tags
  - Key-value pairs



# Amazon EFS – Key Points

- Amazon EFS provides **file storage over a network**
- Perfect for **big data analytics, media processing workflows, content management, web serving, and home directories**
- Fully managed service that **eliminates storage administration tasks**
- Accessible from management console, CLI, or APIs
- Scales up or down as **files are added or removed**

# Lecture's Agenda

- Amazon Elastic Block Store (Amazon EBS)
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# Amazon S3 Glacier

- A **data archiving service** designed for security, durability, and an extremely low cost
- Supports **encryption** of data in transit and at rest through Transport Layer Security (TLS)
- Three retrieval options
  - Expedited: 1–5 minutes
  - Standard: 3–5 hours
  - Bulk: 5–12 hours



# Amazon S3 Glacier – Key Terms

## Archive:

- Any **object** that you store in Amazon S3 Glacier
- It is the **base unit of storage** in Amazon S3 Glacier
- Each archive has its own **unique ID**
- Each archive can also have a **description**

# Amazon S3 Glacier – Key Terms (Cont.)

## Vault:

- A container for storing archives
- When you create a vault, you specify the **vault name** and the **Region** where you want to locate the vault

# Amazon S3 Glacier – Key Terms (Cont.)

## Vault Access Policy:

- Determine who can access the data stored in the vault
- Determine what operations users can perform
- One vault access permissions policy can be created for each vault to manage access permissions for that vault
- You can also use a vault lock policy to make sure that a vault cannot be altered
- Each vault can have one vault access policy and one vault lock policy that are attached to it

# Amazon S3 Glacier Use Cases



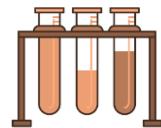
Media asset archiving



Healthcare information archiving



Regulatory and compliance archiving



Scientific data archiving

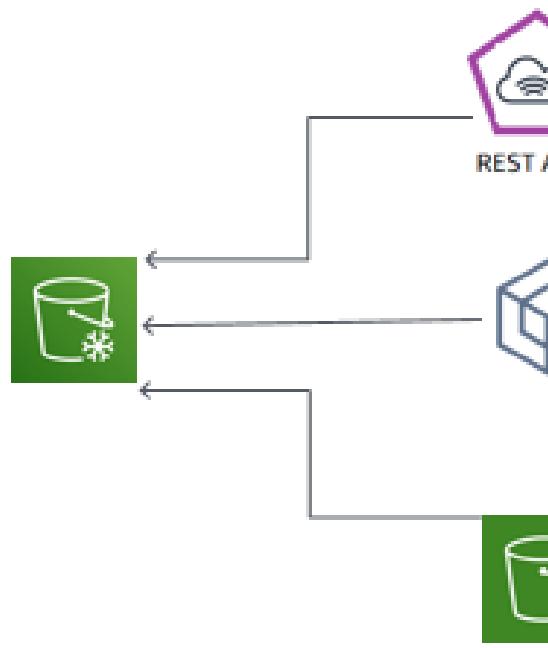


Digital preservation



Magnetic tape replacement

# Using Amazon S3 Glacier



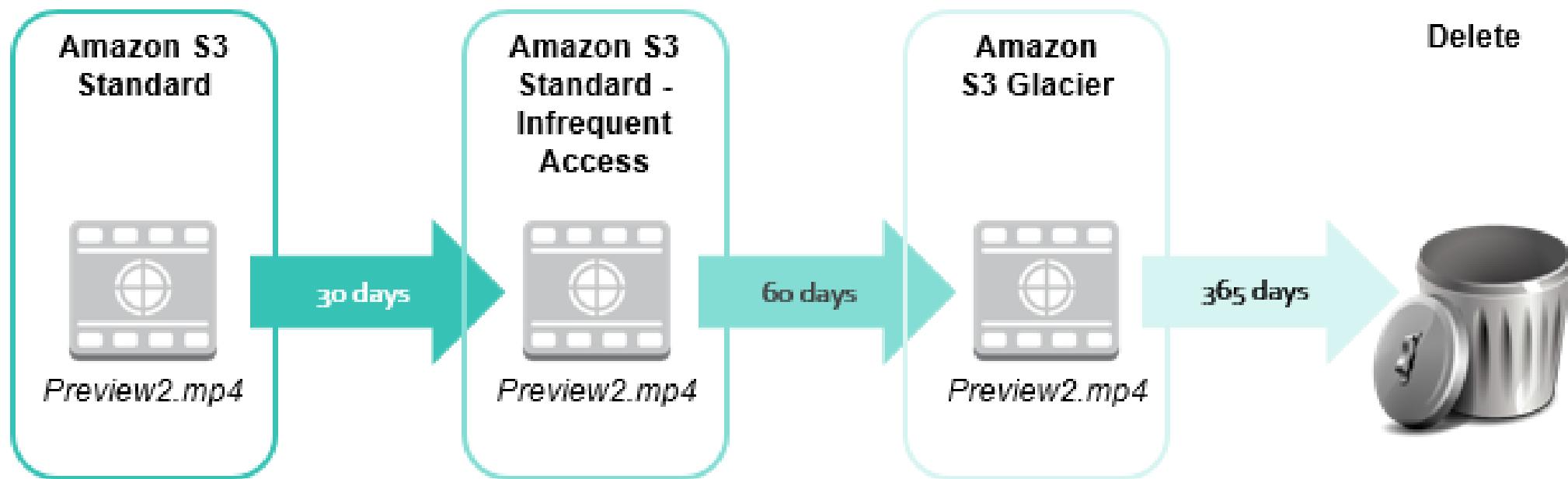
RESTful  
web services

Java or .NET  
SDKs

Amazon S3 with  
lifecycle policies

# Lifecycle Policies

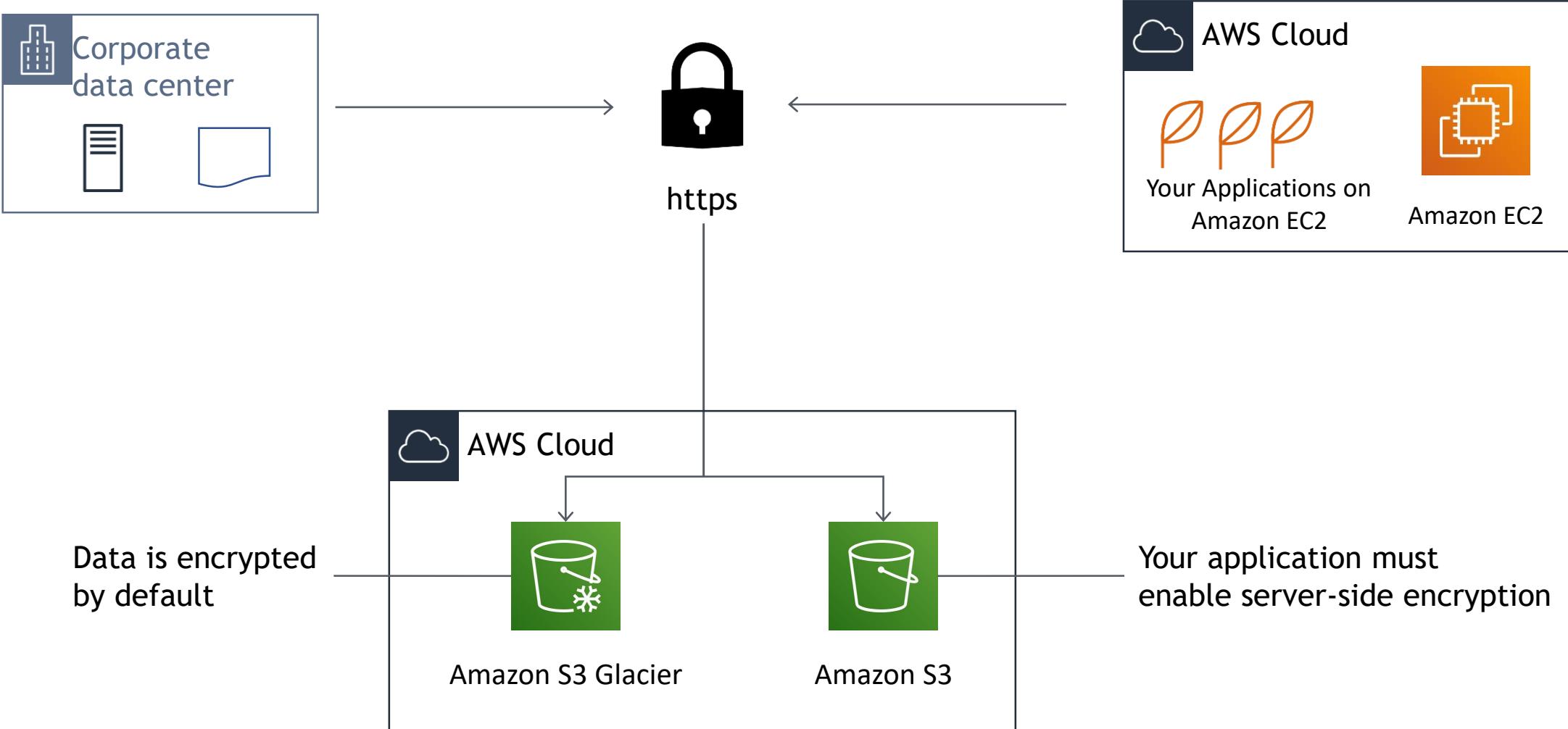
- Amazon S3 lifecycle policies **enable customer** to delete or move objects based on age



# Storage Comparison

	Amazon S3	Amazon S3 Glacier
Data Volume	No limit	No limit
Average Latency	ms	minutes/hours
Item Size	5 TB maximum	40 TB maximum
Cost/GB per Month	Higher cost	Lower cost
Billed Requests	PUT, COPY, POST, LIST, and GET	UPLOAD and retrieval
Retrieval Pricing	¢ Per request	¢¢ Per request and per GB

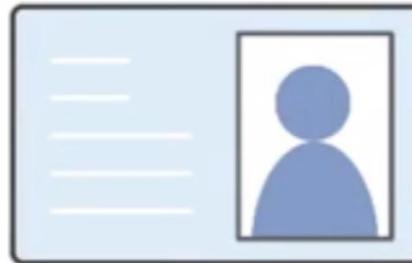
# Server-Side Encryption



# Security with Amazon S3 Glacier



Amazon S3  
Glacier



Control access with  
**IAM**



Amazon S3 Glacier encrypts  
your data with **AES-256**



Amazon S3 Glacier manages  
your **keys** for you

# Amazon S3 Glacier – Key Points

- Amazon S3 Glacier is a **data archiving** service designed for security, durability, and an extremely low cost
- Amazon S3 Glacier **pricing** is based on Region
- Its low-cost design works well for **long-term archiving**
- It is designed to provide **11 9s of durability** for objects

# Additional Resources

- **AWS Storage Page**
  - <https://aws.amazon.com/products/storage/>
- **Storage Overview**
  - <https://docs.aws.amazon.com/whitepapers/latest/aws-overview/storage-services.html>
- **Recovering Files from an Amazon EBS Volume Backup**
  - <https://aws.amazon.com/blogs/compute/recovering-files-from-an-amazon-ebs-volume-backup/>
- **Confused by AWS Storage Options? S3, EFS, EBS Explained**
  - <https://dzone.com/articles/confused-by-aws-storage-options-s3-ebs-and-efs-explained>

Questions?