

AWS Academy Cloud Foundations

Module 7: Storage

Topics

- File , Block, and Object file
- Network-attached storage (NAS)
- Storage area networks (SAN)
- Amazon Elastic Block Store (Amazon EBS)
- Amazon Simple Storage Service (Amazon S3)
- Amazon Elastic File System (Amazon EFS)
- Amazon Simple Storage Service Glacier

Demos

- Amazon EBS console
- Amazon S3 console
- Amazon EFS console
- Amazon S3 Glacier console

Lab

- Working with Amazon EBS

Activities

- Storage solution case study



Knowledge check

Module objectives

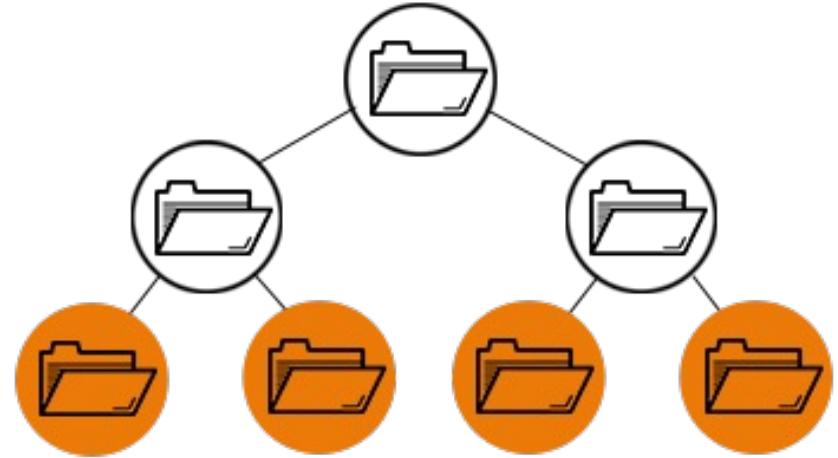


After completing this module, you should be able to:

- Identify the different types of storage
- Explain Amazon S3
- Identify the functionality in Amazon S3
- Explain Amazon EBS
- Identify the functionality in Amazon EBS
- Perform functions in Amazon EBS to build an Amazon EC2 storage solution
- Explain Amazon EFS
- Identify the functionality in Amazon EFS
- Explain Amazon S3 Glacier
- Identify the functionality in Amazon S3 Glacier
- Differentiate between Amazon EBS, Amazon S3, Amazon EFS, and Amazon S3 Glacier

What is file storage?

- File-level or file-based storage
- Data is stored as a single piece of information inside a folder
- Data stored in files is organized and retrieved using a limited amount of metadata that tells the computer exactly where the file itself is kept. It's like a library card catalog for data files.



Reference : <https://www.redhat.com/en/topics/data-storage/file-block-object-storage>

Pros & Cons in file storage



Pros

- Easy to access on a small scale
- Familiar to most users
- Users can manage their own files
- Allows access rights/file sharing/file locking to be set at user level

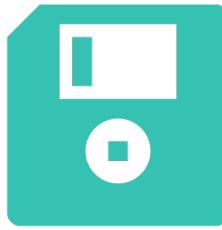
cons

- Challenging to manage and retrieve large numbers of files
- Hard to work with unstructured data
- Becomes expensive at large scales

Reference : <https://www.ibm.com/cloud/blog/object-vs-file-vs-block-storage>



Collaboration of
documents



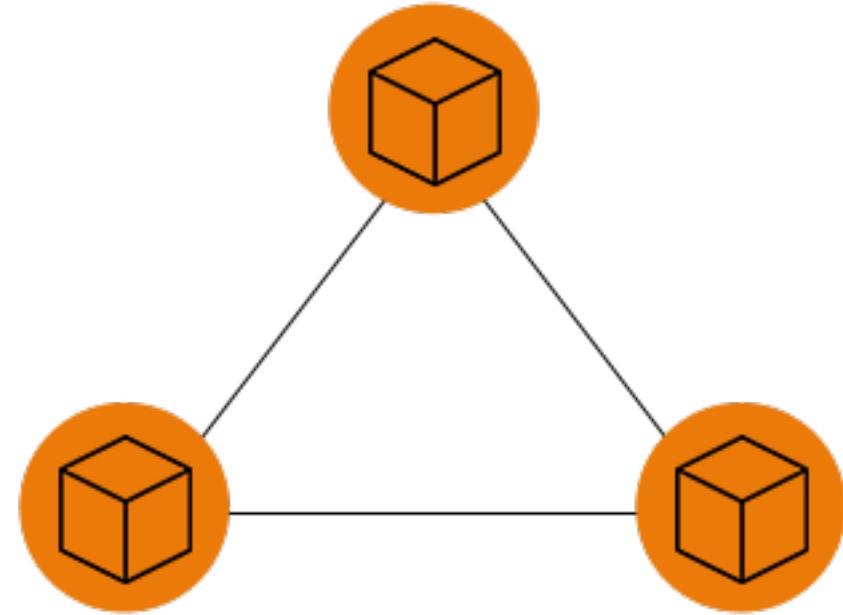
Backup and recovery



Archiving

What is block storage?

- Block storage chops data into blocks and stores them as separate pieces.
- Each block of data is given a unique identifier, which allows a storage system to place the smaller pieces of data wherever is most convenient.
- Stored in a Linux® environment and some can be stored in a Windows unit.



Reference : <https://www.redhat.com/en/topics/data-storage/file-block-object-storage>

Pros & Cons in block storage



Pros

- Fast
- Reliable
- Easy to modify

Cons

- Lack of metadata
- Not searchable
- High cost

Reference : <https://www.ibm.com/cloud/blog/object-vs-file-vs-block-storage>



Databases



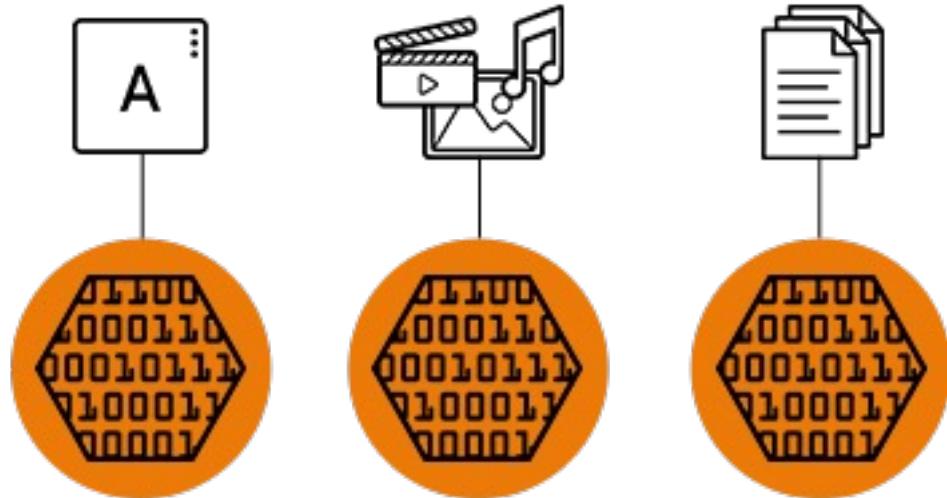
Email servers



Virtual machine file system
(VMFS) volumes

What is object storage?

- Flat structure
- Files are broken into pieces and spread out among hardware.
- Data is broken into discrete units called objects and is kept in a single repository
- no folders or sub-directories



Reference : <https://www.redhat.com/en/topics/data-storage/file-block-object-storage>

Pros & Cons in object storage



PROs

- Handles large amounts of unstructured data
 - ❖ Affordable consumption model
 - ❖ Unlimited scalability
 - ❖ Uses metadata
 - ❖ Advanced search capabilities

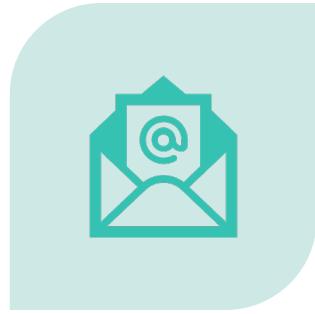
Cons

- Cannot lock files
- Slower performance than other storage types
- Cannot modify a single portion of a file

Reference : <https://www.ibm.com/cloud/blog/object-vs-file-vs-block-storage>



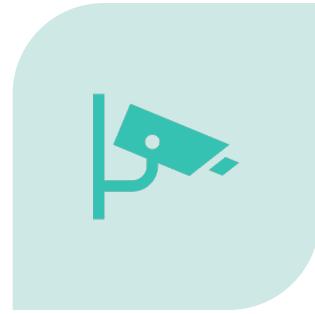
IOT DATA
MANAGEMENT



EMAIL



BACKUP/RECOVERY



VIDEO
SURVEILLANCE

Data storage categorization



Block Storage

stored in chunks known as blocks

stored on a volume and attached to a single instance

Low latency data access

Comparable to DAS storage used on-premises

File Storage

stored as separate files with a series of directories.

File system.

Shared access is provided for multiple users.

Comparable to NAS storage used on-premises

Object Storage

stored across a flat address space

referenced by a unique key

Each object can also have associated metadata to help categorize and identify the object

What are the key differences between object storage, block storage and file storage?



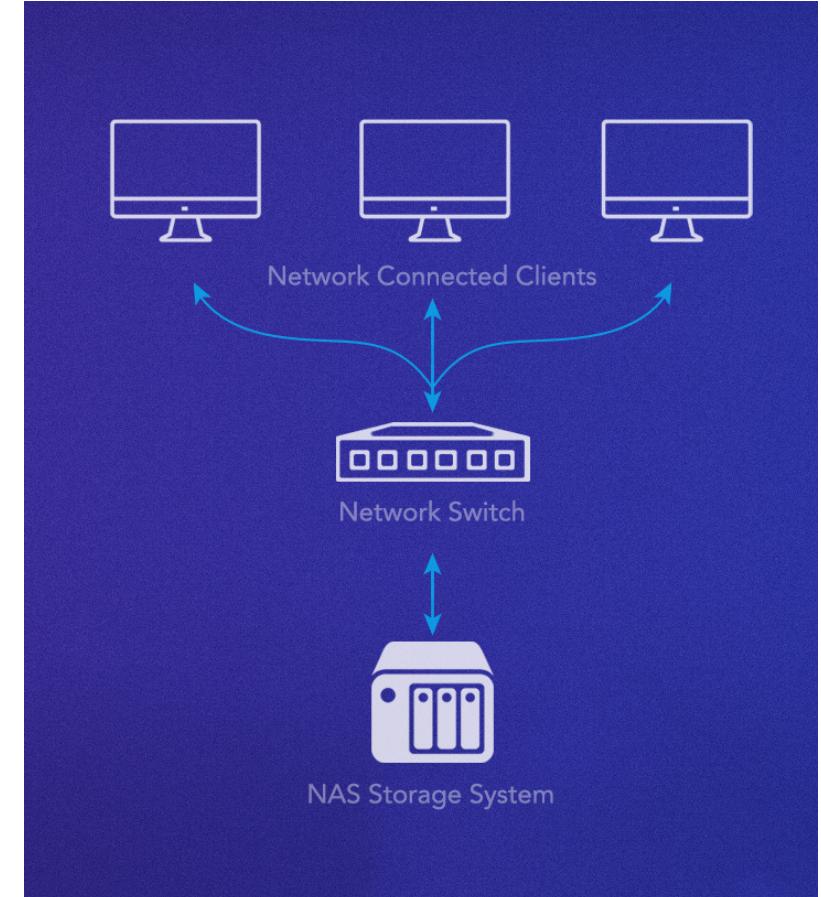
- Cost
- Management ease
- Volume
- Retrievability
- Handling of metadata
- Data protection
- Storage use cases



Reference : <https://www.ibm.com/cloud/blog/object-vs-file-vs-block-storage>

What is network-attached storage?

- Network-attached storage (NAS) is a file-dedicated storage device that makes data continuously available for employees to collaborate effectively over a network.
- Computer network has Interconnected server machines and client machines that send requests to the servers.
- NAS devices are specialized servers that handle only data storage and file-sharing requests.
- Fast, secure, and reliable storage services to private networks.



Why are NAS devices important?



Effective, scalable, and low-cost storage.



NAS file servers give faster data access and are easier to configure and manage.



Support various business applications, including private email systems, accounting databases, payroll, video recording and editing, data logging, and business analytics.

What is network-attached storage used for?

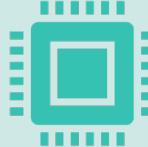


- File storage and sharing
- Create active data archives or for data backup and disaster recovery
- Host virtual desktop infrastructure
- Test and develop web-based and server-side web applications
- Stream media files and torrents
- Store images and videos that require frequent access
- Create an internal printing repository

What are the components of a NAS device?



Physical storage drives



Central processing unit
(CPU)



Operating system



Networking interface

What is the basic storage principle of NAS devices?



- File storage
- Block storage
- Object storage
- File vs. block vs. object storage
 - File storage for local file sharing
 - Block storage for high-performance applications
 - Object storage for unstructured data such as email, videos, image files, web pages, and etc.

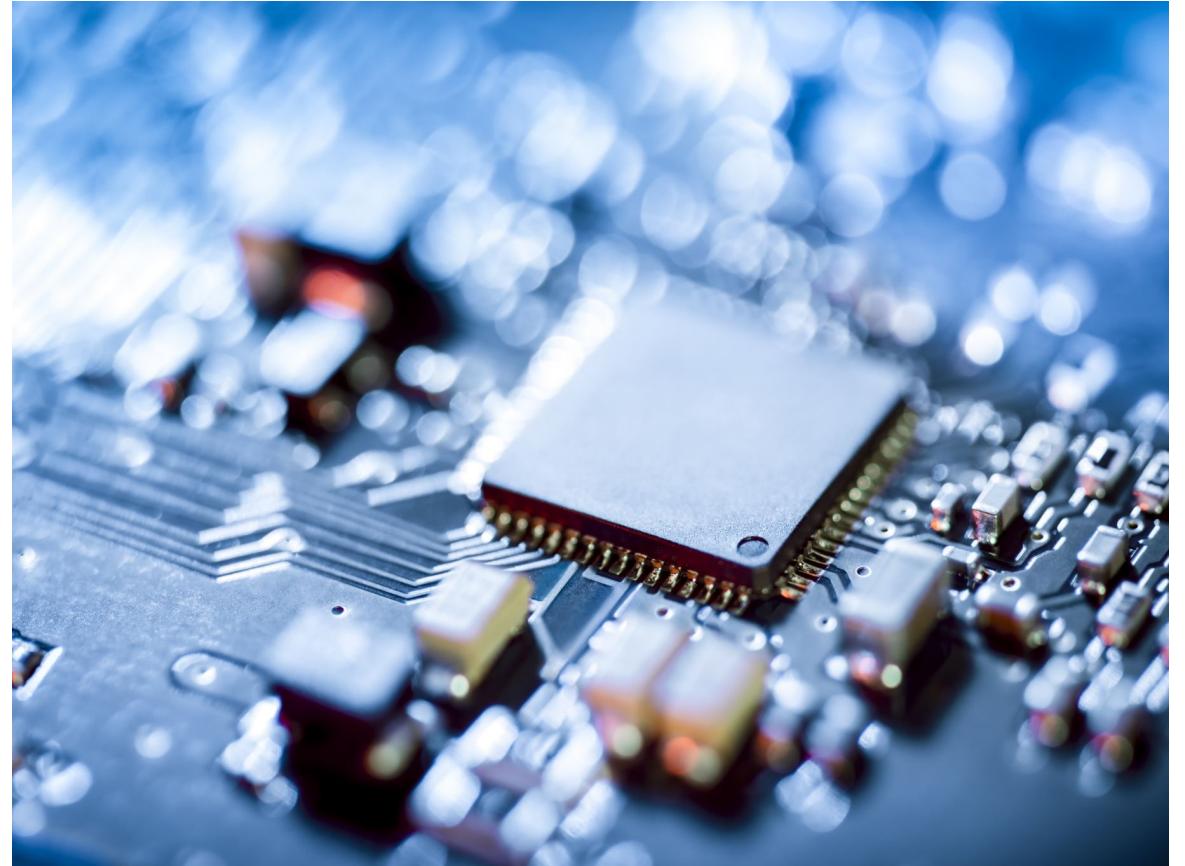
How does NAS work?



- Communication protocols
- File formatting protocols
- Network file systems (NFS)
- Server message blocks (SMB)
- Apple filing protocol (AFP)

What are the different types of NAS devices?

- Computer-based NAS
- Embedded system NAS
- Integrated chip-based NAS



What are the limitations of NAS?

- Difficult to scale
- No service guarantees



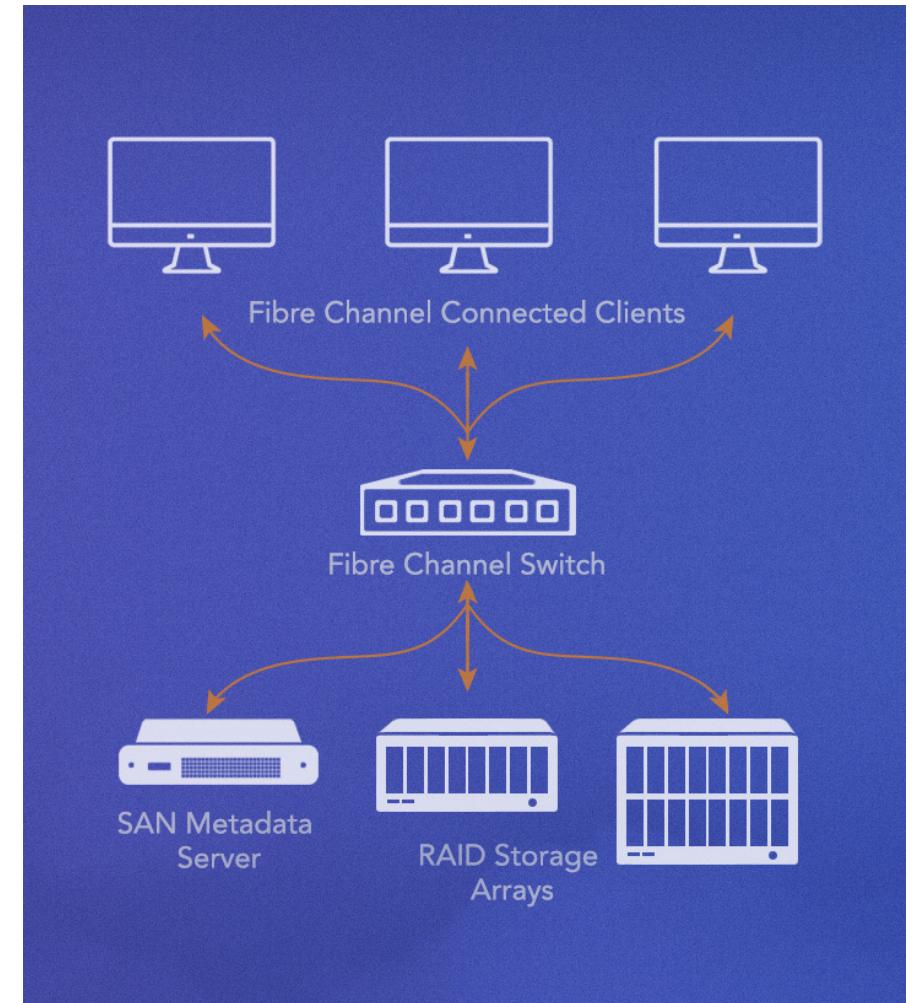
How can users overcome NAS limitations?



- Add more NAS devices
- Unified storage
- Cloud storage
- Benefits of cloud storage

What is storage area networks (SAN)?

- Provide users high-performance, low-latency shared access to storage.
- Built from a combination of servers and storage over a high speed, low latency interconnect.
 - direct Fiber Channel connections
- Require a separate, private Ethernet network between the server and clients to keep the file request traffic out of the Fiber Channel network for even more performance.
- Flexible way to deliver shared storage
- Ensuring the highest access speed available for media and mission critical stored data.



Benefits of SAN



- Extremely fast data access with low latency.
- Relieves stress on a local area network.
- Can be scaled up to the limits of the interconnect.
- OS level (“native”) access to files.
- Often the only solution for demanding applications requiring concurrent shared access.

What are the limitations of SAN?



- Cost and administration requirements.
- Provide very fast data access for many users that also can scale to supporting hundreds of users at the same time.

How does NAS compare to other storage network architectures?



- Storage area networks (SAN) : block storage to networked devices
- NAS vs. SAN
 - **NAS** works as a file system and **SAN** works as the operating system.
 - **NAS** handles individual file requests, but **SAN** manages requests for contiguous blocks of data.
 - NAS and SAN also use different underlying protocols and technologies.
- Direct-attached storage (DAS) : directly attached to a single computer.
- NAS vs. DAS
 - DAS was the precursor to NAS.
 - DAS performs better than NAS
 - For Directly attached, it does not lend itself well to sharing and is complex to manage.

The Main Differences Between NAS and SAN



NAS	SAN
Often used in homes and small to medium sized businesses.	Often used in professional and enterprise environments.
Less expensive.	More expensive.
Easier to manage.	Requires more administration.
Data accessed as if it were a network-attached drive.	Servers access data as if it were a local hard drive.
Speed dependent on local TCP/IP Ethernet network, typically 1GbE to 10GbE, and affected by the number of other users accessing the storage at the same time. Generally slower throughput and higher latency due to the nature of Ethernet packetization, waiting for the file server, and latency in general.	High speed using Fibre Channel, most commonly available in 16 Gb/s to 32 Gb/s. Fibre Channel can be delivered via high speed Ethernet such as 10Gb or 40Gb+ networks using protocols such as FCoE and iSCSI.
SMB/CIFS, NFS, SFTP, and WebDAV.	Fibre Channel, iSCSI, FCoE.
Lower-end not highly scalable; high-end NAS scale to petabytes using clusters or scale-out nodes.	Can add more storage controllers, or expanded storage arrays allowing SAN admins to scale performance, storage, or both.
Simply connects to your existing Ethernet network.	Requires dedicated Fibre Channel connections for clients, servers, and storage, and often a separate, dedicated Ethernet network for file request traffic.
Entry level systems often have a single point of failure, e.g. power supply.	Fault tolerant network and systems with redundant functionality.
Subject to general Ethernet issues.	Behavior is more predictable in controlled, dedicated environments.
A central place from which to back up or sync user files.	A place from which to archive files not immediately needed.

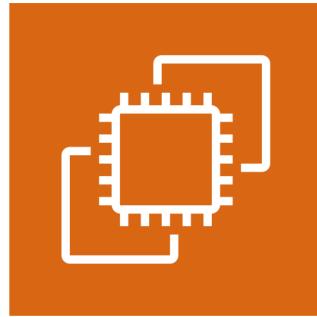
How can AWS help with storage solutions?

- AWS Storage Services
 - Amazon Elastic Block Store (EBS)
 - Amazon Elastic File System
 - Amazon Simple Storage Service (Amazon S3)

Core AWS services



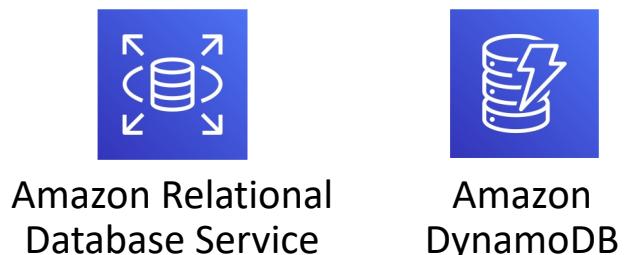
**Amazon Virtual
Private Cloud
(Amazon VPC)**



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



Storage



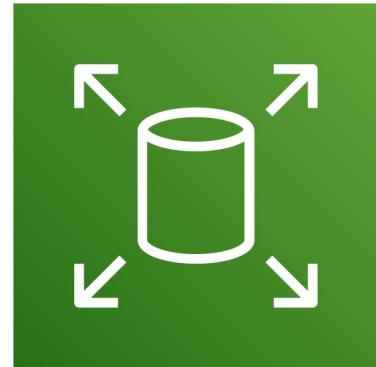
Database



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

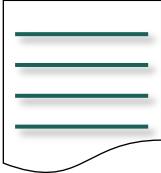
Module 7: Storage

Section 1: Amazon Elastic Block Store (Amazon EBS)

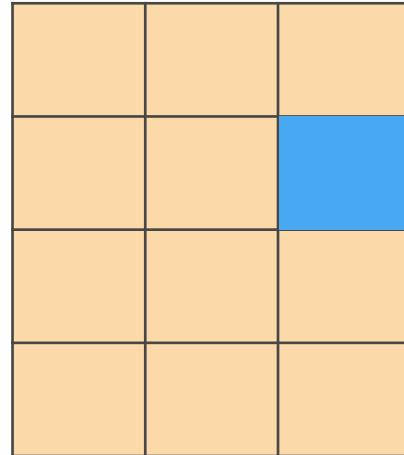


Amazon Elastic Block Store
(Amazon EBS)

AWS storage options: Block storage versus object storage

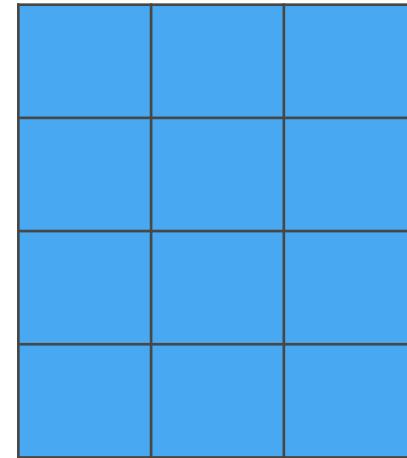


What if you want to change one character in a 1-GB file?



Block storage

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



Object storage

Entire file must be updated

Amazon EBS enables you to **create individual storage volumes** and **attach them** to an Amazon EC2 instance:

- Amazon EBS offers block-level storage.
- Volumes are automatically replicated within its Availability Zone.
- It can be backed up automatically to Amazon S3 through snapshots.
- Uses include –
 - Boot volumes and storage for Amazon Elastic Compute Cloud (Amazon EC2) instances
 - 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

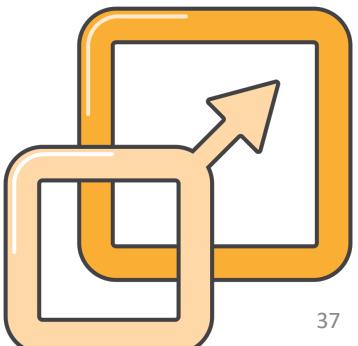
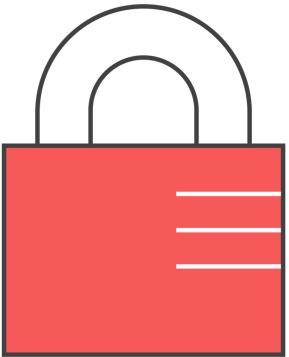
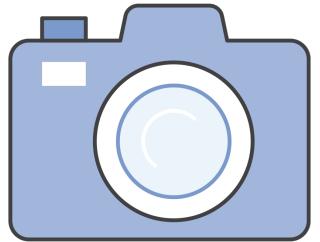
Amazon EBS volume type use cases



Solid State Drives (SSD)		Hard Disk Drives (HDD)	
General Purpose	Provisioned IOPS	Throughput-Optimized	Cold
<ul style="list-style-type: none">This type is recommended for most workloadsSystem boot volumesVirtual desktopsLow-latency interactive applicationsDevelopment and test environments	<ul style="list-style-type: none">Critical business applications that require sustained IOPS performance, or more than 16,000 IOPS or 250 MiB/second of throughput per volumeLarge database workloads	<ul style="list-style-type: none">Streaming workloads that require consistent, fast throughput at a low priceBig dataData warehousesLog processingIt cannot be a boot volume	<ul style="list-style-type: none">Throughput-oriented storage for large volumes of data that is infrequently accessedScenarios where the lowest storage cost is importantIt cannot be a boot volume

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



1. Volumes –

- Amazon EBS volumes persist independently from the instance.
- All volume types are charged by the amount that is provisioned per month.

2. IOPS –

- General Purpose SSD:
 - Charged by the amount that you provision in GB per month until storage is released.
- Magnetic:
 - Charged by the number of requests to the volume.
- Provisioned IOPS SSD:
 - Charged by the amount that you provision in IOPS (multiplied by the percentage of days that you provision for the month).

3. Snapshots –

- Added cost of Amazon EBS snapshots to Amazon S3 is per GB-month of data stored.

4. Data transfer –

- Inbound data transfer is free.
- Outbound data transfer across Regions incurs charges.

Section 1 key takeaways



Amazon EBS features:

- Persistent and customizable block storage for Amazon EC2
- HDD and SSD types
- Replicated in the same Availability Zone
- Easy and transparent encryption
- Elastic volumes
- Back up by using snapshots

Recorded demo: Amazon Elastic Block Store



[Elastic Block Store demo](#)

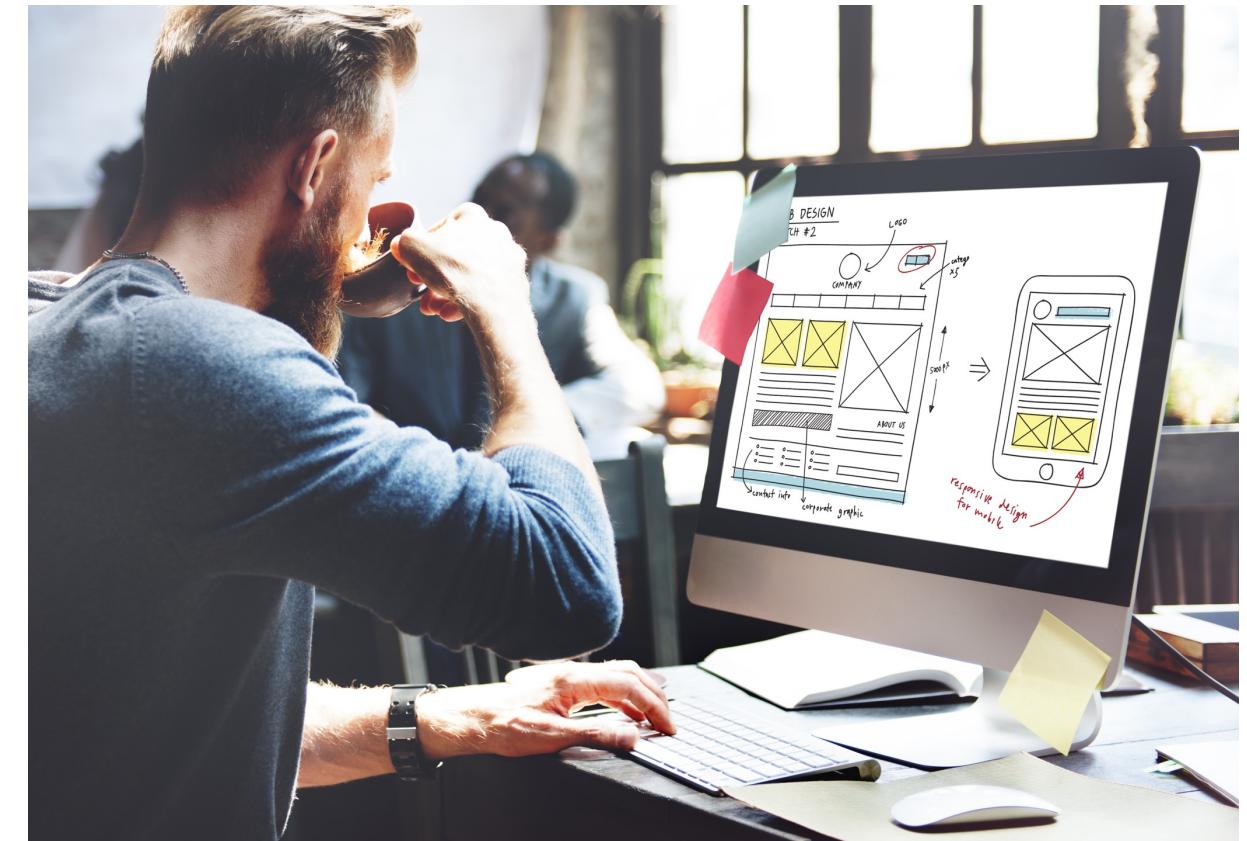


Set up demo

Amazon Elastic Block Store (EBS)



Lab 4: Working with Amazon EBS



Lab 4: 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: Final product





~ 30 minutes



Begin Lab 4: Working with Amazon EBS

Lab debrief: Key takeaways



Module 7: Storage

Section 2: Amazon Simple Storage Service (Amazon S3)



**Amazon Simple Storage Service
(Amazon S3)**

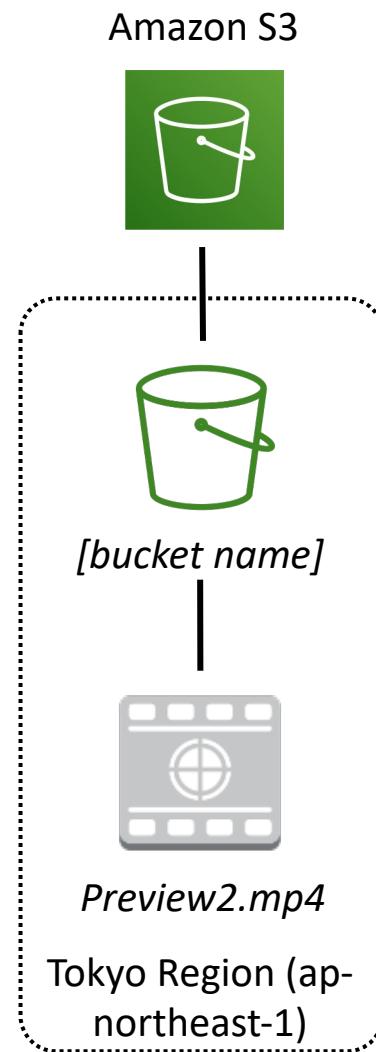
- Data is stored as objects in buckets
- Virtually unlimited storage
 - Single object is limited to 5 TB
- Designed for 11 9s of durability
- Granular access to bucket and objects



Amazon S3 offers a range of object-level storage classes that are designed for different use cases:

- Amazon S3 Standard
- Amazon S3 Intelligent-Tiering
- Amazon S3 Standard-Infrequent Access (Amazon S3 Standard-IA)
- Amazon S3 One Zone-Infrequent Access (Amazon S3 One Zone-IA)
- Amazon S3 Glacier
- Amazon S3 Glacier Deep Archive

Amazon S3 bucket URLs (two styles)



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

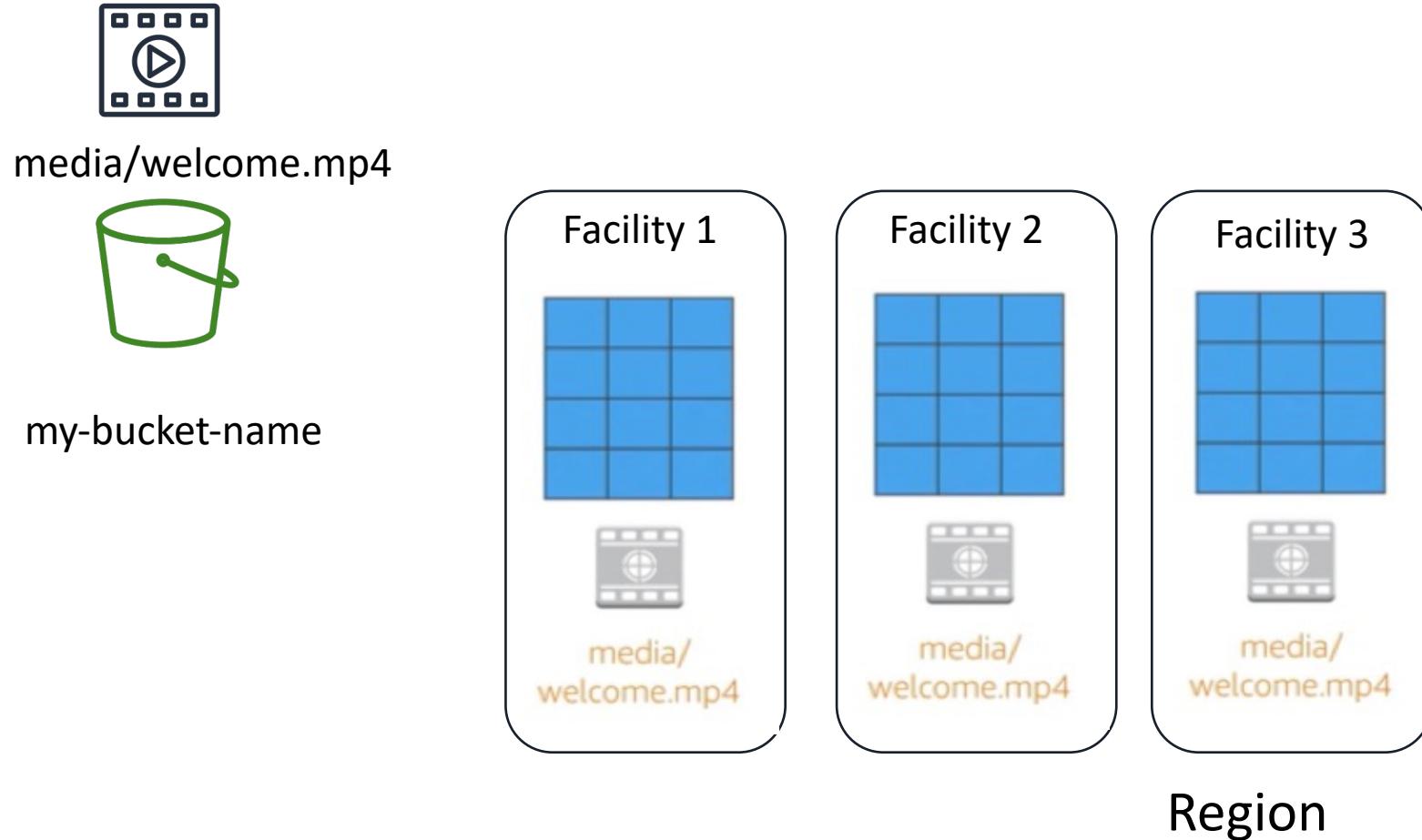
Bucket virtual hosted-style URL endpoint:

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

Bucket name

Region code

Data is redundantly stored in the Region



Designed for seamless scaling



my-bucket-name



media/welcome.mp4



prod2.mp4



prod3.mp4



prod4.mp4



prod5.mp4



prod6.mp4



prod7.mp4



prod8.mp4



prod9.mp4



prod10.mp4

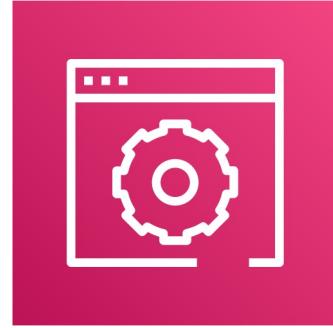


prod11.mp4

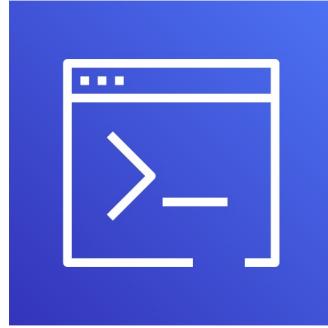


prod12.mp4

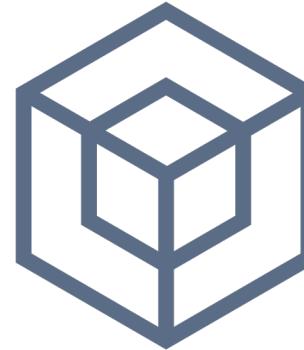
Access the data anywhere



AWS Management
Console



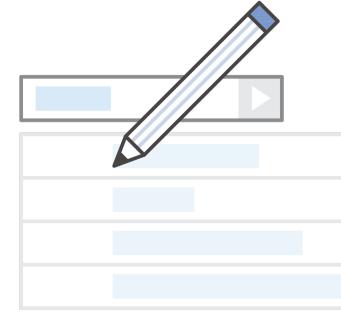
AWS Command Line
Interface



SDK

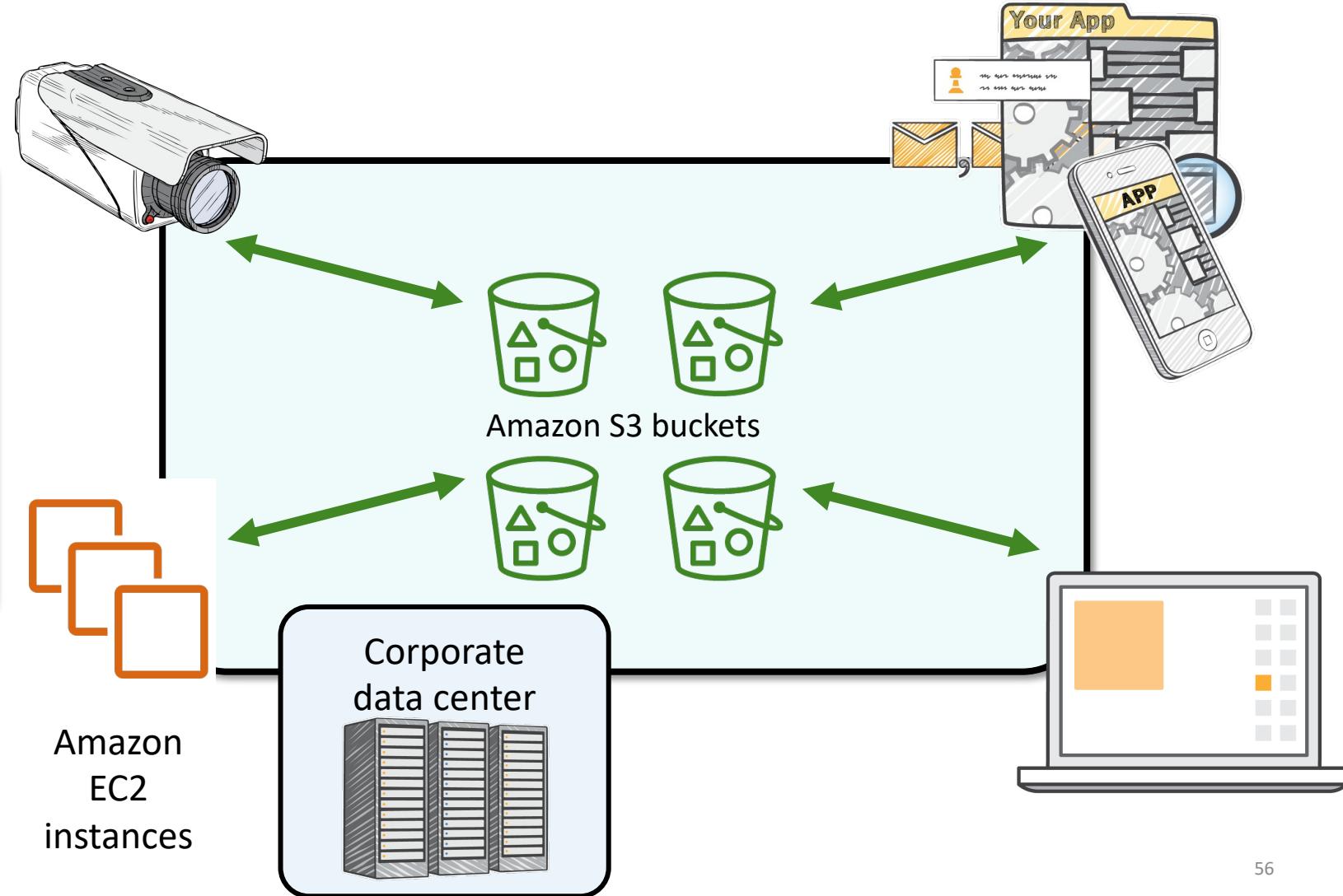
Common use cases

- Storing application assets
- Static web hosting
- Backup and disaster recovery (DR)
- Staging area for big data
- *Many more....*



Amazon S3 common scenarios

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



- Pay only for what you use, including –
 - 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

To estimate Amazon S3 costs, consider the following:

1. 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

2. Amount of storage –

- The number and size of objects

3. Requests –

- The number and type of requests (**GET, PUT, COPY**)
- Type of requests:
 - Different rates for GET requests than other requests.

4. 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.

Section 2 key takeaways



- Amazon S3 is a fully managed cloud storage service.
- You can store a virtually unlimited number of objects.
- You pay for only what you use.
- You can access Amazon S3 at any time from anywhere through a URL.
- Amazon S3 offers rich security controls.

Recorded demo: Amazon Simple Storage System



Set up demo

Amazon S3



Module 7: Storage

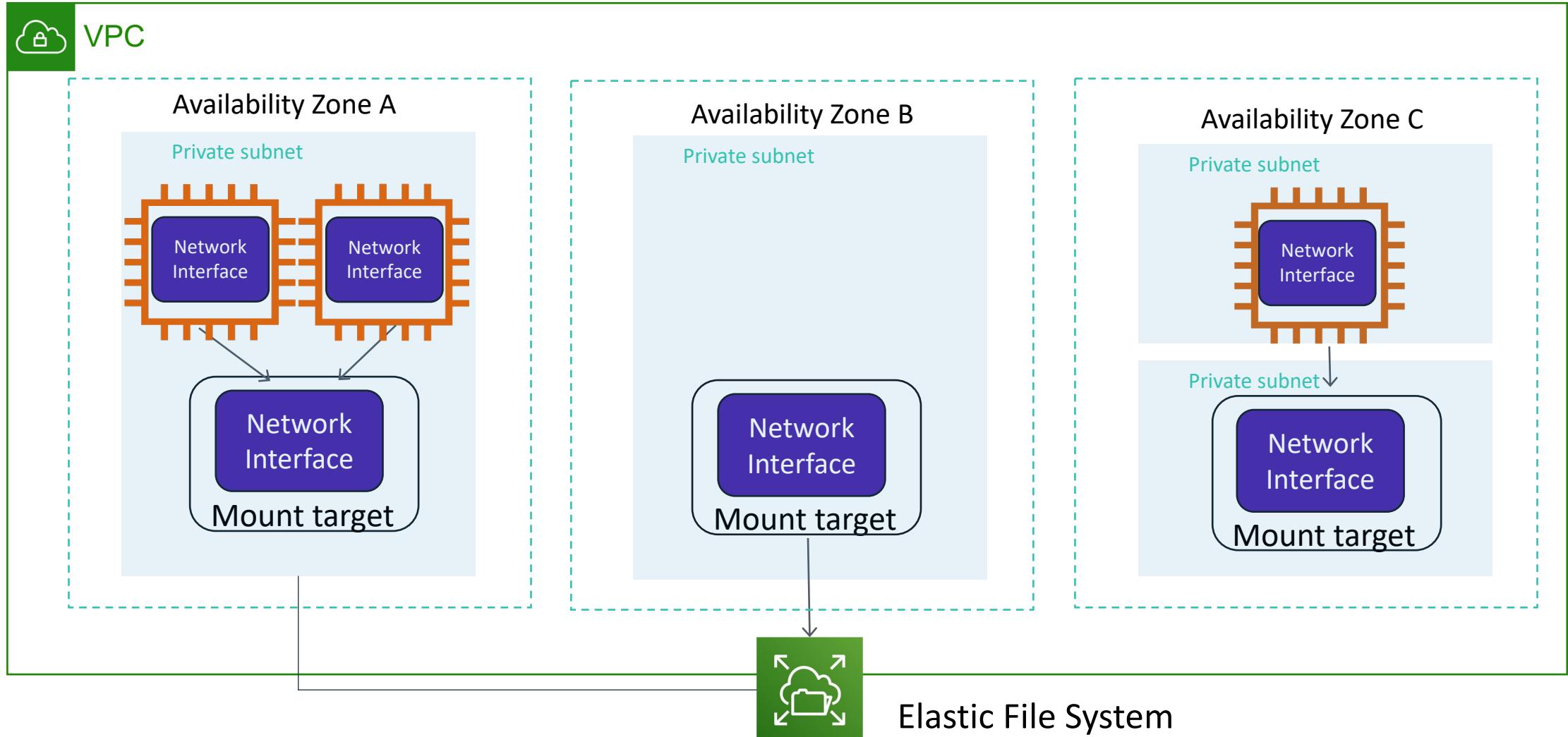
Section 3: Amazon Elastic File System (Amazon EFS)



Amazon Elastic File System (Amazon EFS)

- File storage in the AWS Cloud
- Works well for big data and analytics, media processing workflows, content management, web serving, and home directories
- Petabyte-scale, low-latency file system
- Shared storage
- Elastic capacity
- Supports Network File System (NFS) versions 4.0 and 4.1 (NFSv4)
- Compatible with all Linux-based AMIs for Amazon EC2

Amazon EFS architecture



Amazon EFS implementation



- ① Create your Amazon EC2 resources and launch your Amazon EC2 instance.
- ② Create your Amazon EFS file system.
- ③ Create your mount targets in the appropriate subnets.
- ④ Connect your Amazon EC2 instances to the mount targets.
- ⑤ Verify the resources and protection of your AWS account.

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



Section 3 key takeaways



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

Recorded demo: Amazon Elastic File System



Set up demo

Amazon Elastic File System
(Amazon EFS)

A dark blue rectangular area containing text, with a faint, darker version of the wireframe cube background visible on the right side.

Module 7: Storage

Section 4: Amazon S3 Glacier



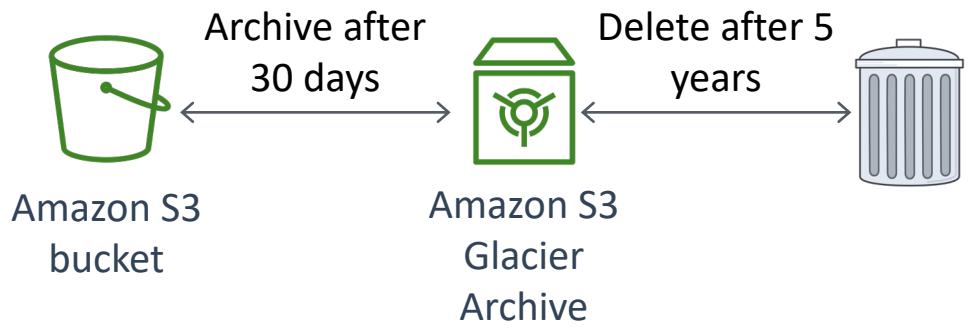
Amazon S3 Glacier

Amazon S3 Glacier is a **data archiving service** that is designed for **security**, **durability**, and an **extremely low cost**.

- Amazon S3 Glacier is designed to provide 11 9s of durability for objects.
- It supports the encryption of data in transit and at rest through Secure Sockets Layer (SSL) or Transport Layer Security (TLS).
- The Vault Lock feature enforces compliance through a policy.
- Extremely low-cost design works well for long-term archiving.
 - Provides three options for access to archives—expedited, standard, and bulk—retrieval times range from a few minutes to several hours.

Amazon S3 Glacier

- Storage service for low-cost data archiving and long-term backup
- You can configure lifecycle archiving of Amazon S3 content to Amazon S3 Glacier
- Retrieval options –
 - Standard: 3–5 hours
 - Bulk: 5–12 hours
 - Expedited: 1–5 minutes





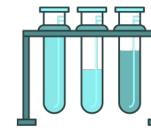
Media asset archiving



Healthcare information archiving



Regulatory and compliance archiving



Scientific data archiving

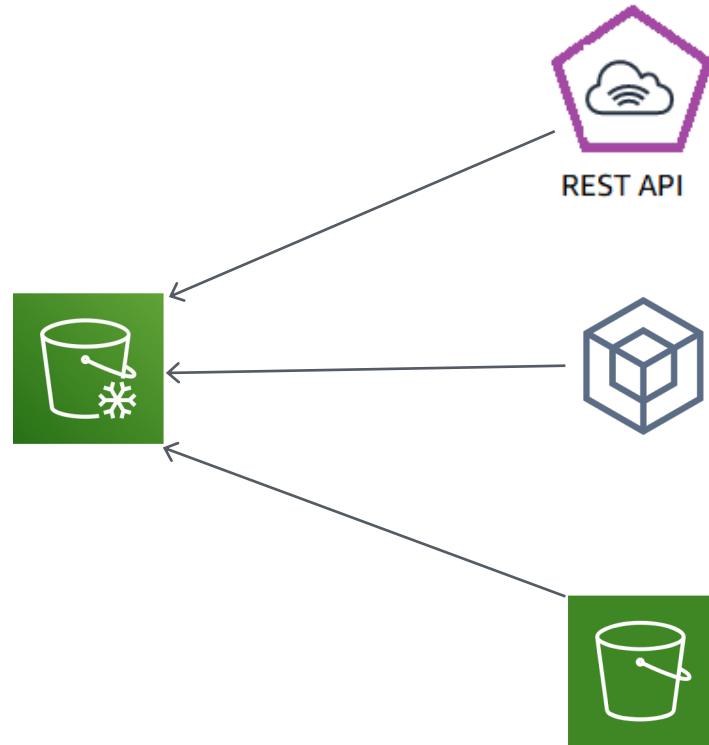


Digital preservation



Magnetic tape replacement

Using Amazon S3 Glacier



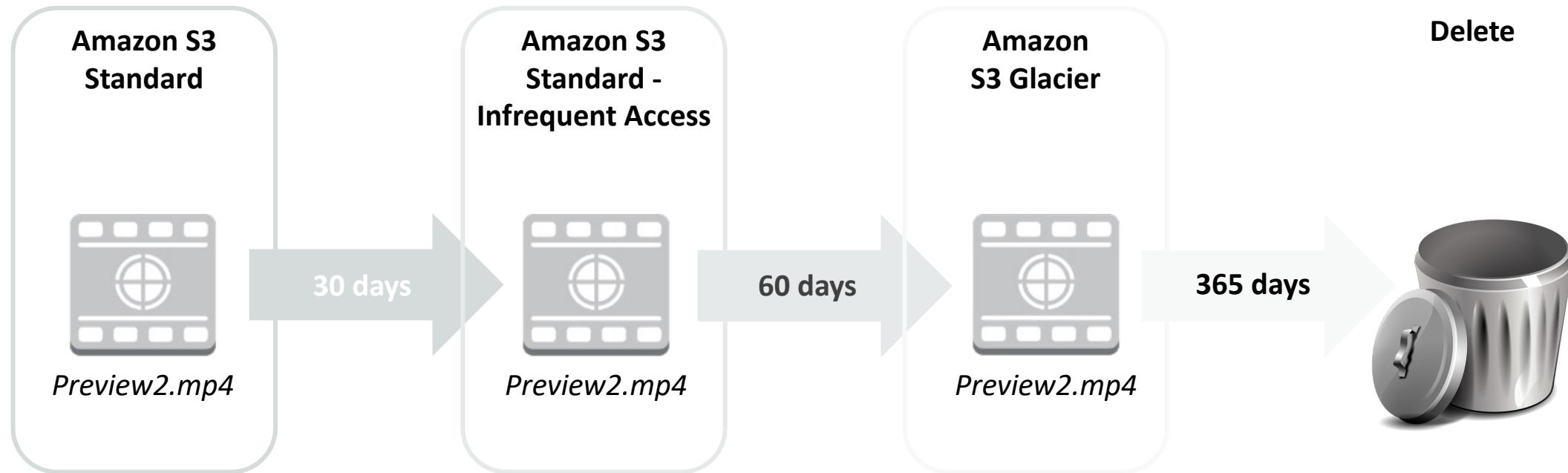
RESTful
web services

Java or .NET
SDKs

Amazon S3 with
lifecycle policies

Lifecycle policies

Amazon S3 lifecycle policies enable you to delete or move objects based on age.

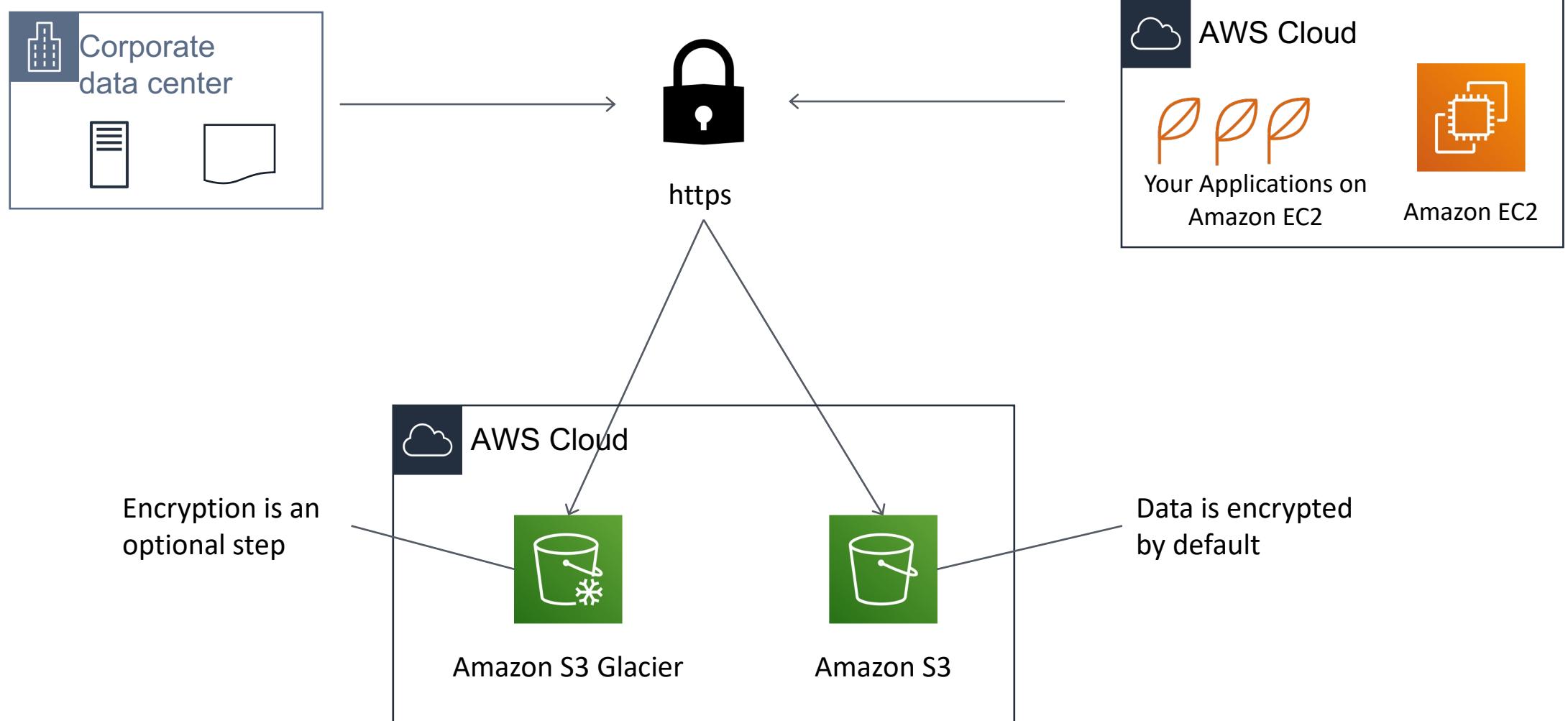


Storage comparison



	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

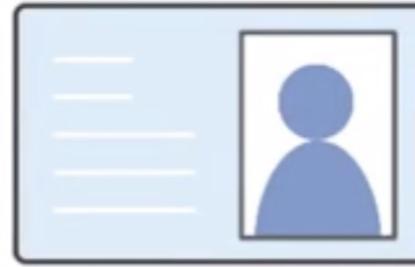
Server-side encryption



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**

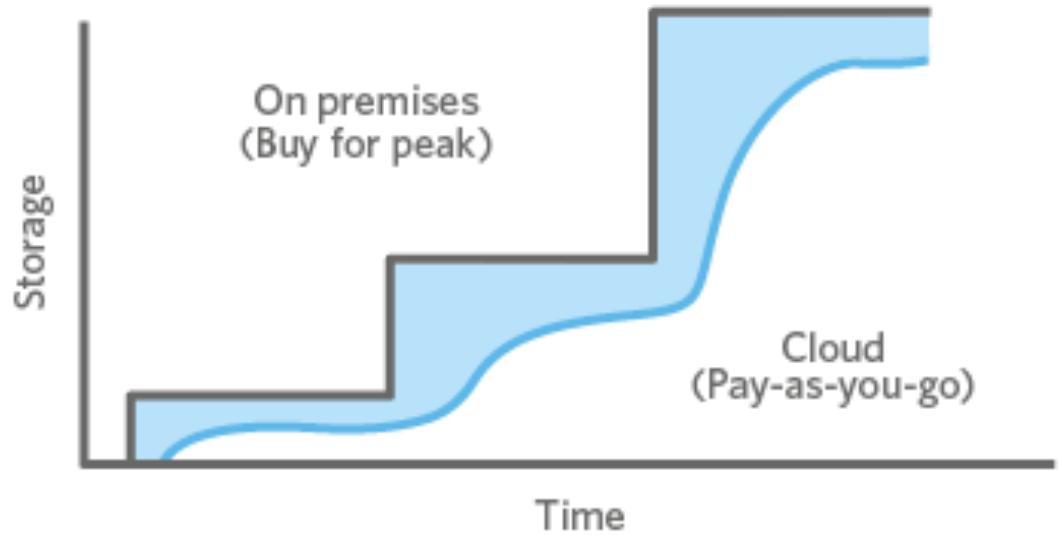
Section 4 key takeaways



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

Benefits of Cloud Storage

- Total Cost of Ownership
- Time to Deployment
- Information Management



Recorded demo:
Amazon S3 Glacier



Set up demo

Amazon Glacier



Amazon FSx for Windows File Server



- FSx provided fully managed, highly reliable, and scalable file storage.
- Supported the industry-standard SMB protocol
- It is built on Windows Server, delivering a wide range of administrative features such as user quotas, end-user file restores, and Microsoft Active Directory integration.
- It offers Single-AZ and Multi-AZ deployment options, fully managed backups, and encryption of data at rest and in transit.
- Amazon FSx file storage is accessible from Windows, Linux, and macOS compute instances and devices running on AWS or on-premises.
- Optimize cost and performance for your workload needs with SSD and HDD storage options.

Amazon FSx for Windows File Server *features*



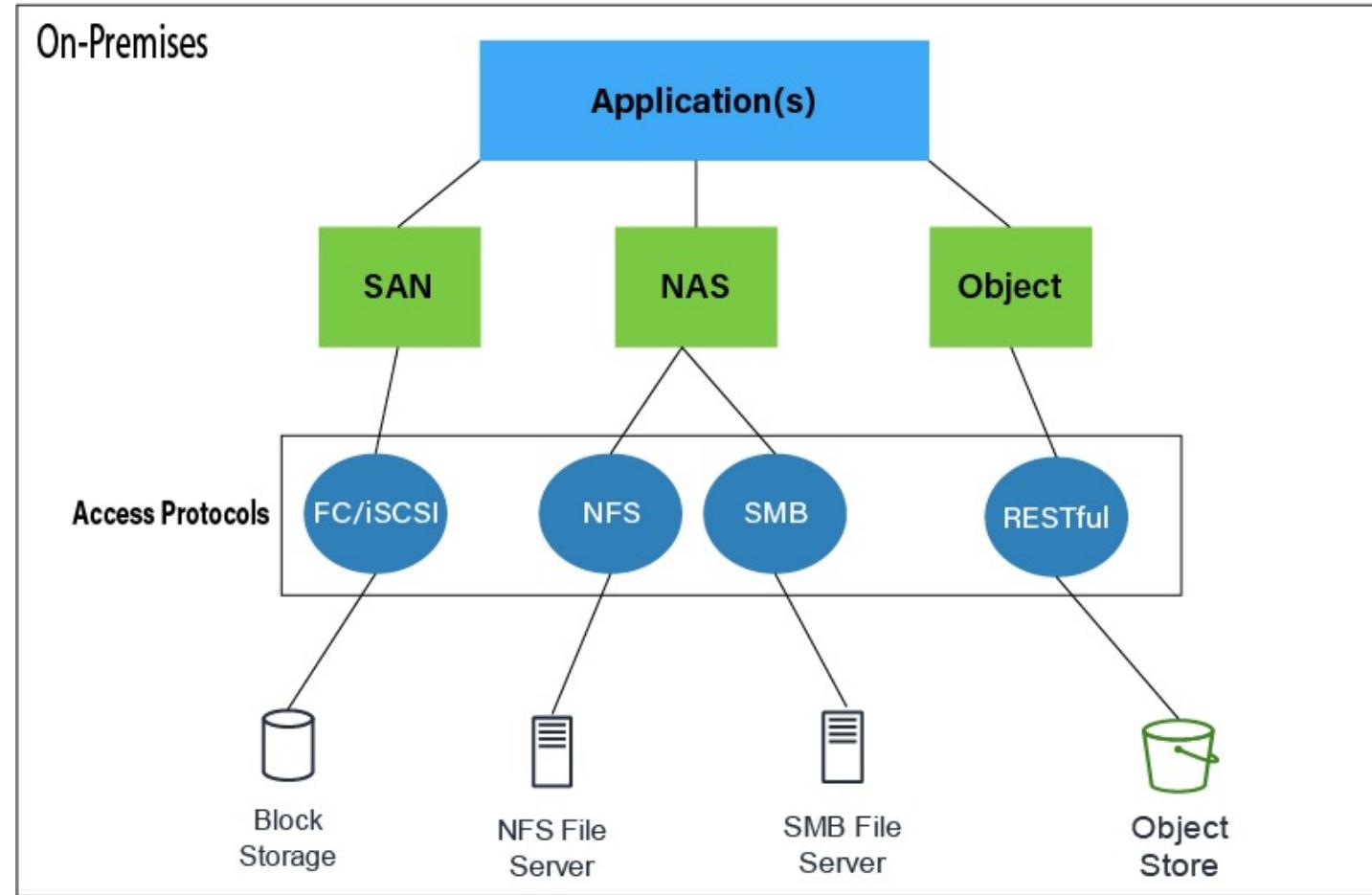
Fully featured and compatible

Protocol and OS support	Performance and scale	Cost optimization
✓ Full SMB protocol support	✓ Consistent, sub-millisecond latencies	✓ Storage type flexibility (SSD / HDD)
✓ Access from Windows Server 2008+	✓ PB-scale storage scalability	✓ Deployment type flexibility (Single-AZ / Multi-AZ)
✓ Access from Windows 7+	✓ Tens of GB/s throughput scalability	✓ Select throughput and storage independently
✓ Access from Linux	✓ Millions of IOPS scalability	✓ Data deduplication and compression
✓ Access from MacOS	✓ Server-side and client-side caching	✓ User storage quotas
Compute instance accessibility	SMB MultiChannel	
✓ EC2, WorkSpaces and AppStream 2.0	✓ Monitor performance via CloudWatch	
✓ VMware Cloud on AWS		
✓ ECS and EKS containers		
✓ Lambda (via PySMB)		
Availability, durability, and backups		
✓ Cross-VPC/Account/Region access	✓ High availability: automatic recovery	✓ Active Directory integration
✓ Shared VPC access	✓ High durability: automatic replication	✓ Encryption at-rest and in-transit
✓ On-prem access (DirectConnect/VPN)	✓ Multi-AZ deployment	✓ PCI DSS, ISO, SOC, and HIPAA compliances
	✓ SMB Continuous Availability	✓ File access control via NTFS ACLs
	✓ Snapshots (with end-user file-restore)	✓ Network traffic access control via VPC
	✓ Backups	✓ Administration access control via IAM

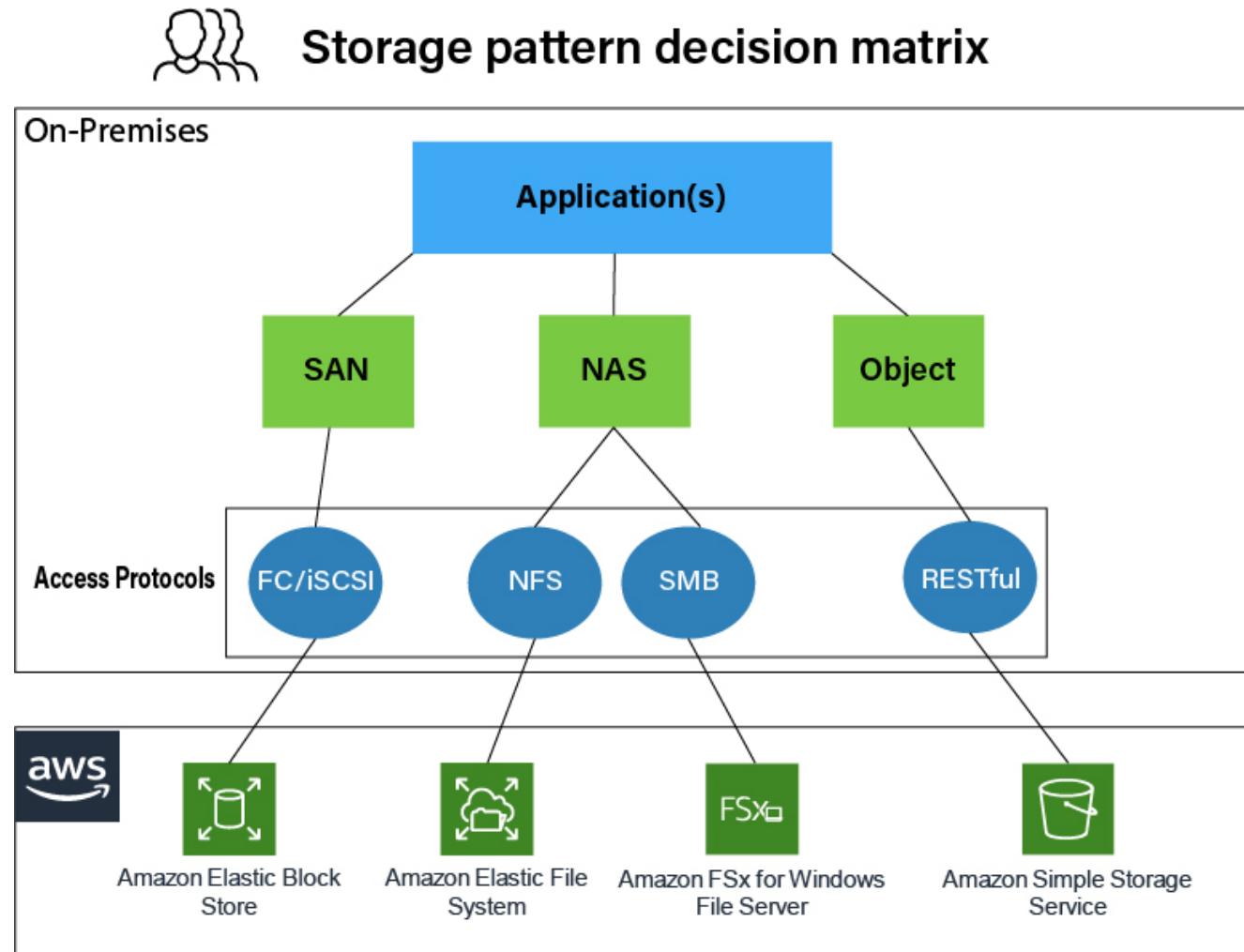
On-premises storage decision matrix



Storage pattern decision matrix



AWS Storage pattern decision matrix



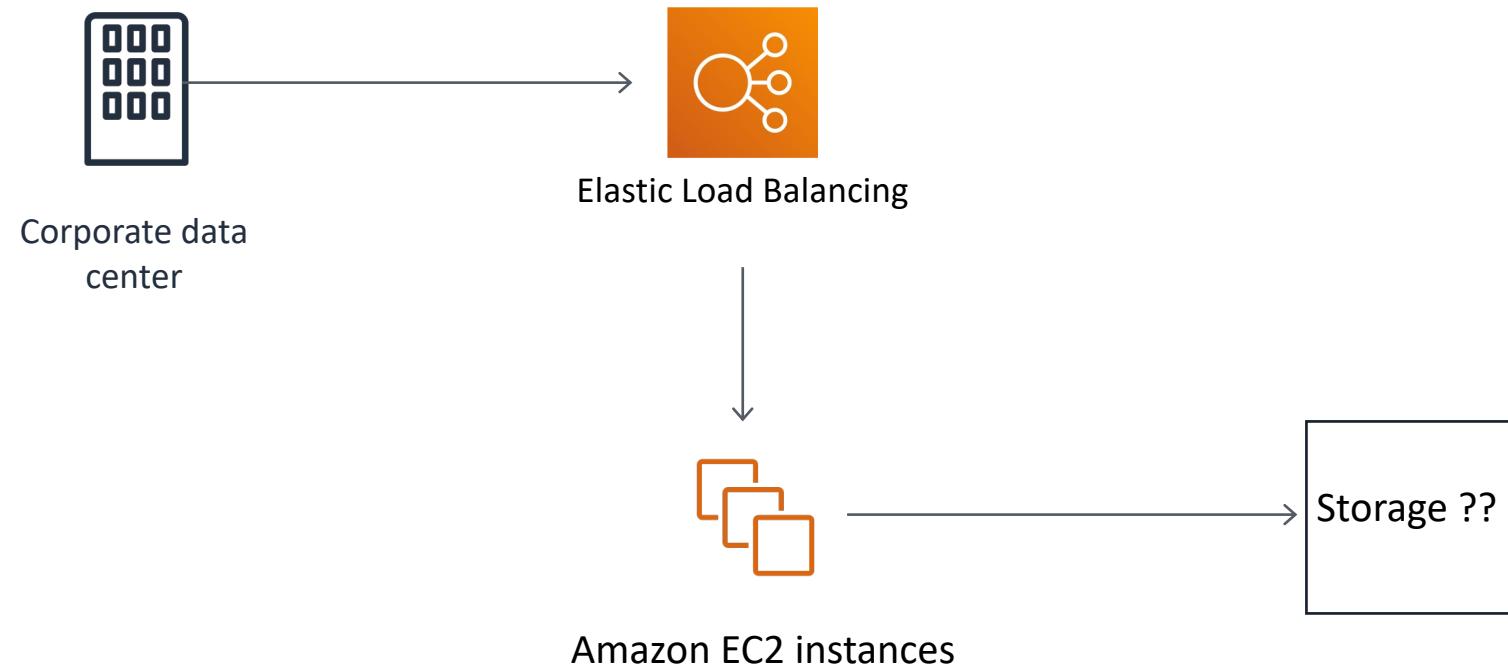
Activity: Storage Case Studies



Photo by panumas nikhomkhai from Pexels.

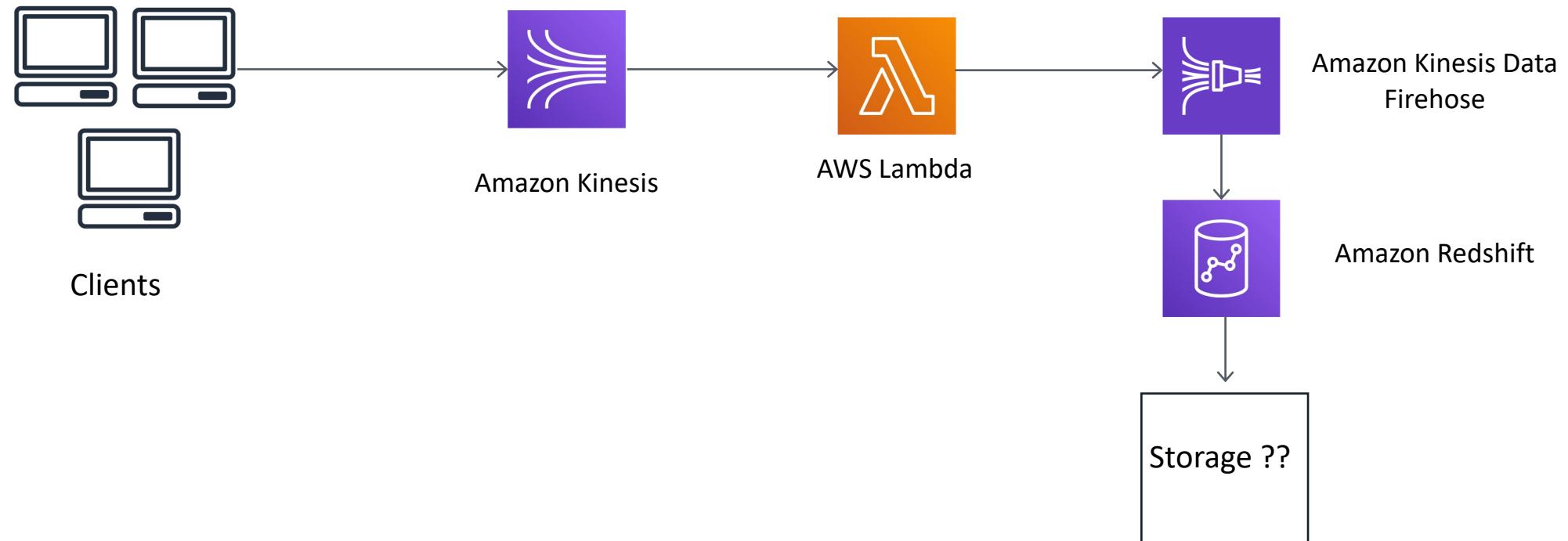
Storage case study activity

Case 1: A collaboration software company processes email for enterprise customers. They have more than 250 enterprise customers and more than half a million users. They must store petabytes of data for their customers. The following diagram illustrates their architecture.



Storage case study activity

Case 2: A financial data processing and consulting company must store large amounts of data for compliance reasons. They use Amazon Kinesis for processing the data and Amazon Redshift for analysis. The following diagram illustrates their architecture.



Module 7: Storage

Module wrap-up

Module summary



In summary, in this module, you learned how to:

- Identify the different types of storage
- Explain Amazon S3
- Identify the functionality in Amazon S3
- Explain Amazon EBS
- Identify the functionality in Amazon EBS
- Perform functions in Amazon EBS to build an Amazon EC2 storage solution
- Explain Amazon EFS
- Identify the functionality in Amazon EFS
- Explain Amazon S3 Glacier
- Identify the functionality in Amazon S3 Glacier
- Differentiate between Amazon EBS, Amazon S3, Amazon EFS, and Amazon S3 Glacier

Complete the knowledge check



Sample exam question

A company wants to store data that is not frequently accessed. What is the best and cost-effective solution that should be considered?

- A. AWS Storage Gateway
- B. Amazon Simple Storage Service Glacier
- C. Amazon Elastic Block Store (Amazon EBS)
- D. Amazon Simple Storage Service (Amazon S3)

Additional resources



- [AWS Storage page](#)
- [Storage Overview](#)
- [Recovering files from an Amazon EBS volume backup](#)
- [Confused by AWS Storage Options? S3, EFS, EBS Explained](#)

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