

Amazon EC2 – Instance Storage

What's an EBS Volume?

- An **EBS (Elastic Block Store) Volume** is a **network drive** you can attach to your instances while they run.
- It allows your instances to **persist data**, even after their termination.
- **They can only be mounted to one instance at a time** (at the CCP level).
- They are bound to a **specific Availability Zone (AZ)**.

Analogy

- Think of them as a "**network USB stick**".

Free Tier

- 30 GB of free EBS storage per month (General Purpose SSD or Magnetic).

EBS Volume

It's a network drive (i.e. not a physical drive)

- It uses the **network** to communicate with the instance, so **latency** may be present.
- It can be **detached** from one EC2 instance and **re-attached** to another one quickly.

It's locked to an Availability Zone (AZ)

- An EBS Volume in `us-east-1a` **cannot** be attached to `us-east-1b`.
- To move a volume across AZs, you must first **snapshot** it.

Have a provisioned capacity (size in GBs and IOPS)

- You are **billed** for all provisioned capacity.
- Capacity can be **increased over time**.

EBS – Delete on Termination attribute

- Controls the EBS behaviour when an EC2 instance terminates:
 - By default, the **root EBS volume is deleted** (attribute enabled).
 - By default, **any other attached EBS volume is not deleted** (attribute disabled).
- This attribute can be controlled via:
 - **AWS Console**
 - **AWS CLI**

Use case:

- Preserve the root volume **after an EC2 instance is terminated**, e.g. for data recovery or forensic purposes.

EBS Snapshots

- You can make a **backup (snapshot)** of your EBS volume at a specific point in time.
- **Detaching the volume is not necessary** to perform a snapshot, but it is recommended for data consistency.
- **Snapshots can be copied** across:
 - **Availability Zones (AZ)**

- **Regions**

Example

An EBS volume in `us-east-1a` (50 GB) is snapshotted and the snapshot can be used to **restore** the volume in another AZ or Region (e.g., `us-east-1b`).

EBS Snapshots Features

EBS Snapshot Archive

- Move a snapshot to an **archive tier** that is up to **75% cheaper**.
- **Restore time** from archive: **24 to 72 hours**.

Recycle Bin for EBS Snapshots

- You can configure **retention rules** to keep deleted snapshots, allowing recovery after accidental deletion.
- Retention period can be set from **1 day to 1 year**.

Fast Snapshot Restore (FSR)

- Forces **full initialization** of a snapshot to ensure **zero latency** on first use.
- This feature has an **additional cost**.

Example

- You can **archive** a snapshot to reduce costs (but with slower restore).
- Deleted snapshots can be sent to a **recycle bin** for recovery within the configured retention period.

AMI Overview

- **AMI = Amazon Machine Image**
- AMIs are a **customization** of an EC2 instance:
 - You add your own software, configuration, operating system, monitoring, etc.
 - Faster boot/configuration time since all your software is pre-packaged.
- AMIs are built for a **specific region** (but can be copied across regions).
- You can launch EC2 instances from:
 - **A Public AMI**: provided by AWS
 - **Your own AMI**: created and maintained by you
 - **An AWS Marketplace AMI**: created by someone else and possibly sold

AMI Process (from an EC2 instance)

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

EC2 Instance Store

- EBS volumes are **network drives** with good but *limited* performance
- If you need a **high-performance hardware disk**, use EC2 Instance Store

Characteristics:

- Better I/O performance
- EC2 Instance Store loses its storage if the instance is stopped (ephemeral)
- Good for buffer / cache / scratch data / temporary content
- Risk of data loss if hardware fails
- **Backups and Replication are your responsibility**

Local EC2 Instance Store – Very High IOPS

Performance by Instance Size

Instance Size	100% Random Read IOPS	Write IOPS
i3.large*	100,125	35,000
i3.xlarge*	206,250	70,000
i3.2xlarge	412,500	180,000
i3.4xlarge	825,000	360,000
i3.8xlarge	1.65 million	720,000
i3.16xlarge	3.3 million	1.4 million
i3.metal	3.3 million	1.4 million
i3en.large*	42,500	32,500
i3en.xlarge*	85,000	65,000
i3en.2xlarge*	170,000	130,000
i3en.3xlarge	250,000	200,000
i3en.6xlarge	500,000	400,000
i3en.12xlarge	1 million	800,000
i3en.24xlarge	2 million	1.6 million
i3en.metal	2 million	1.6 million

EBS Volume Types

- EBS Volumes come in 6 types:
 - **gp2 / gp3 (SSD)**: General purpose SSD volume that balances price and performance for a wide variety of workloads
 - **io1 / io2 Block Express (SSD)**: Highest-performance SSD volume for mission-critical, low-latency or high-throughput workloads
 - **st1 (HDD)**: Low cost HDD volume designed for frequently accessed, throughput-intensive workloads
 - **sc1 (HDD)**: Lowest cost HDD volume designed for less frequently accessed workloads

- EBS Volumes are characterized in:
 - **Size**
 - **Throughput**
 - **IOPS (I/O Operations Per Second)**
- When in doubt, always consult the AWS documentation – it's good!
- **Only gp2/gp3 and io1/io2 Block Express can be used as boot volumes**

EBS Volume Types Use Cases

General Purpose SSD

- Cost effective storage, low-latency
- Suitable for:
 - System boot volumes
 - Virtual desktops
 - Development and test environments
- Volume size range: **1 GiB – 16 TiB**

gp3:

- Baseline: **3,000 IOPS** and **125 MiB/s** throughput
- Can increase:
 - IOPS up to **16,000**
 - Throughput up to **1,000 MiB/s**
- IOPS and throughput can be configured **independently**

gp2:

- Small volumes can **burst IOPS to 3,000**
- Volume size and IOPS are **linked**:
 - **3 IOPS per GiB**
 - Max IOPS: **16,000**
- At **5,334 GiB**, you reach the **maximum IOPS** ($5,334 \times 3 = 16,002$)

EBS Volume Types Use Cases

Provisioned IOPS (PIOPS) SSD

- Designed for **critical business applications** with sustained IOPS performance
- Suitable for applications that need **more than 16,000 IOPS**
- Ideal for **database workloads**, where storage performance and consistency are critical

io1 (4 GiB – 16 TiB):

- Max PIOPS:
 - **64,000** for **Nitro EC2 instances**
 - **32,000** for other instances
- PIOPS can be **increased independently** from storage size

io2 Block Express (4 GiB – 64 TiB):

- **Sub-millisecond latency**

- Max PIOPS: **256,000**
 - IOPS:GiB ratio up to **1,000:1**
- Supports **EBS Multi-Attach**

EBS Volume Types Use Cases

Hard Disk Drives (HDD)

- **Cannot be used as boot volume**
- Volume size range: **125 GiB – 16 TiB**

Throughput Optimized HDD (st1)

- Use cases:
 - Big Data
 - Data Warehouses
 - Log Processing
- **Max throughput:** 500 MiB/s
- **Max IOPS:** 500

Cold HDD (sc1)

- Use cases:
 - Infrequently accessed data
 - Cost-sensitive scenarios
- **Max throughput:** 250 MiB/s
- **Max IOPS:** 250

EBS – Volume Types Summary

Volume Type	Durability	Use Cases	Volume Size	Max IOPS per Volume	Max Throughput per Volume	EBS Multi-Attach	NVM Reserva
gp3 (General Purpose SSD)	99.8% - 99.9% (0.1% - 0.2% AFR)	- Transactional workloads - Virtual desktops - Medium-sized DBs - Low-latency apps - Boot volumes - Dev & test	1 GiB – 16 TiB	16,000	1,000 MiB/s	Not supported	Not support
gp2 (General Purpose SSD)	99.8% - 99.9% (0.1% - 0.2% AFR)	Same as gp3	1 GiB – 16 TiB	16,000 (3 IOPS per GiB)	250 MiB/s	Not supported	Not support

io2 Block Express (PIOPS)	99.999% (0.001% AFR)	- Sub-millisecond latency - Sustained IOPS - > 64,000 IOPS or 1,000 MiB/s	4 GiB – 64 TiB	256,000	4,000 MiB/s	Supported	Support
io1 (PIOPS)	99.8% - 99.9% (0.1% - 0.2% AFR)	- Sustained IOPS - > 16,000 IOPS - I/O-intensive DB workloads	4 GiB – 16 TiB	64,000 (Nitro) / 32,000	1,000 MiB/s	Supported	Not support
st1 (Throughput HDD)	99.8% - 99.9% (0.1% - 0.2% AFR)	- Big Data - Data warehouses - Log processing	125 GiB – 16 TiB	500	500 MiB/s	Not supported	-
sc1 (Cold HDD)	99.8% - 99.9% (0.1% - 0.2% AFR)	- Infrequently accessed data - Lowest cost scenarios	125 GiB – 16 TiB	250	250 MiB/s	Not supported	-

 [AWS Docs Reference](#)

EBS Multi-Attach – io1/io2 Family

- Allows attaching the **same EBS volume** to **multiple EC2 instances** within the **same Availability Zone**
- Each instance has **full read & write permissions** to the high-performance volume

Use Cases

- Achieve **higher application availability** in clustered Linux applications (e.g. Teradata)
- Applications must **handle concurrent write operations**

Key Characteristics

- Supports up to **16 EC2 instances simultaneously**
- Requires a **cluster-aware file system** (e.g. not XFS, EXT4)

Example: A single io2 volume is shared by up to 16 EC2 instances within the same AZ

EBS Encryption

When you create an encrypted EBS volume, you get:

- **Data at rest** is encrypted inside the volume
- **Data in flight** (between the instance and the volume) is encrypted
- **All snapshots** of the volume are encrypted
- **All volumes** created from encrypted snapshots are also encrypted

Key Points

- Encryption and decryption are handled **transparently** (no user action needed)
- **Minimal impact on latency**
- Uses **AWS KMS (AES-256)** for encryption keys
- **Copying an unencrypted snapshot** allows encryption
- **Snapshots of encrypted volumes are always encrypted**

Encryption: Encrypt an Unencrypted EBS Volume

Steps to encrypt an existing unencrypted EBS volume:

1. **Create an EBS snapshot** of the unencrypted volume
2. **Encrypt the snapshot** using the **Copy** action
3. **Create a new EBS volume** from the encrypted snapshot
 - The new volume will be **encrypted**
4. **Attach the encrypted volume** to the original EC2 instance (if needed)

Amazon EFS – Elastic File System

- **Managed NFS** (Network File System) that can be mounted on **multiple EC2 instances**
- Works with EC2 instances in **multi-AZ**
- **Highly available, scalable**, and **expensive** (approximately **3× gp2**)
- **Pay-per-use** pricing model

Key Characteristics

- Ideal for **shared access** across AZs
- Automatically scales with usage
- EC2 instances access EFS through a **Security Group**

Example: EC2 instances in us-east-1a, 1b, and 1c are connected to a shared EFS filesystem via a Security Group, supporting multi-AZ shared storage.

Amazon EFS – Elastic File System

Use Cases

- Content management
- Web serving
- Data sharing
- Wordpress hosting

Key Features

- Uses **NFSv4.1 protocol**
- Access is controlled via **Security Groups**
- **Compatible only with Linux-based AMIs** (not Windows)
- Encryption at rest using **AWS KMS**

File System Characteristics

- **POSIX-compliant** (standard Linux file API)
- Automatically scales
- **Pay-per-use**, no need for capacity planning

EFS – Performance & Storage Classes

EFS Scale

- Supports **thousands of concurrent NFS clients**
- Up to **10 GB/s throughput**
- **Automatically scales** to petabyte-scale file systems

Performance Mode (*set at EFS creation time*)

- **General Purpose (default):**
 - Best for **latency-sensitive** use cases (e.g. web server, CMS)
- **Max I/O:**
 - Higher latency, but optimized for **throughput and parallelism**
 - Suitable for **big data, media processing**

Throughput Mode

- **Bursting:**
 - Baseline: **1 TB = 50 MiB/s**
 - Burst capacity: **up to 100 MiB/s**
- **Provisioned:**
 - Set fixed throughput, e.g. **1 GiB/s for 1 TB storage**, regardless of actual size
- **Elastic:**
 - Automatically adjusts throughput based on usage
 - **Up to 3 GiB/s for reads** and **1 GiB/s for writes**
 - Ideal for **unpredictable workloads**

EFS – Storage Classes

Storage Tiers (Managed via Lifecycle Policies)

- **Standard:** For frequently accessed files
- **Infrequent Access (EFS-IA):**
 - Lower storage cost
 - Higher retrieval cost
- **Archive:**
 - For rarely accessed files (a few times per year)
 - 50% cheaper than EFS-IA
- You can **automatically move** files between tiers using **lifecycle policies** (e.g., after 60 days of no access)

Availability and Durability

- **Standard:**
 - **Multi-AZ** (high availability)

- Recommended for production workloads
- **One Zone:**
 - Stored in a **single AZ**
 - Better for development/test
 - Backup enabled by default
 - Compatible with IA → **EFS One Zone-IA**

Key Benefit

- **Over 90% cost savings** with EFS lifecycle tiering

EBS vs EFS – Elastic Block Storage

EBS Volumes

- Can be attached to **one instance only** (except for **multi-attach io1/io2**)
- Are **AZ-bound** (locked to the same Availability Zone)
- **gp2**: IOPS increase with volume size
- **gp3 / io1**: IOPS and throughput can be configured **independently**

To Migrate an EBS Volume Across AZ

1. **Take a snapshot** of the volume
2. **Restore the snapshot** to a volume in a different AZ
3. Note: EBS backups consume **I/O**, so avoid running during peak traffic

Additional Notes

- **Root EBS volumes** are deleted by default when the EC2 instance is terminated
 - This setting **can be disabled**

EBS vs EFS – Elastic File System

EFS Key Features

- Can be mounted to **hundreds of instances across multiple AZs**
- Commonly used to **share website files** (e.g. WordPress)
- **POSIX-compliant**, so it works **only with Linux instances**
- Typically **more expensive than EBS**
- Can reduce cost using **Storage Tiers**

Reminder

- Know when to use:
 - **EFS**: Shared, multi-AZ, scalable file system
 - **EBS**: Single-AZ block storage, low-latency
 - **Instance Store**: Ephemeral storage tied to instance lifecycle