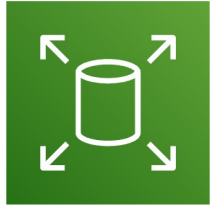


# Amazon EC2 – Instance Storage



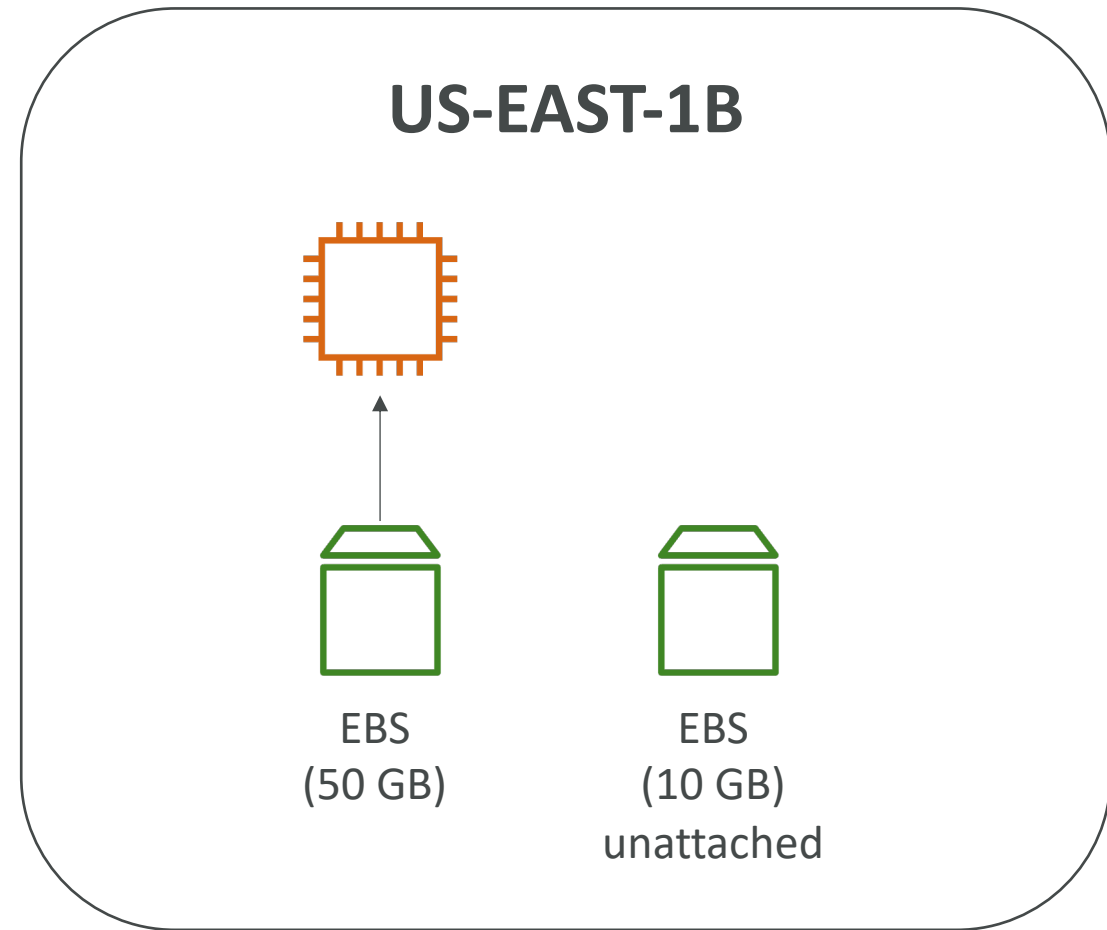
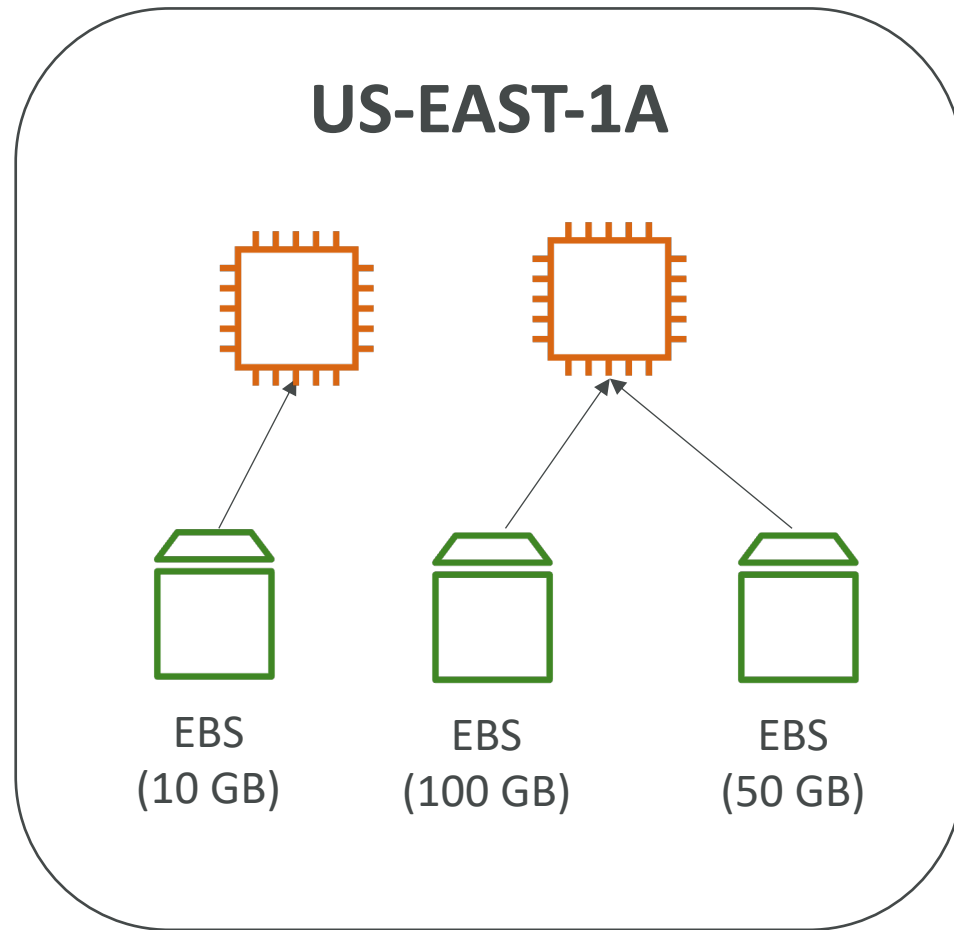
# What's an EBS Volume?

- 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**
- Analogy: Think of them as a “network USB stick”
- Free tier: 30 GB of free EBS storage of type General Purpose (SSD) or Magnetic per month

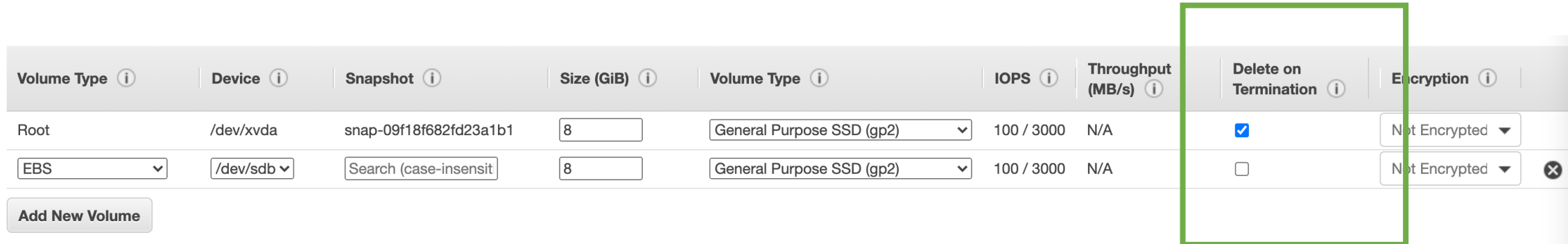
# EBS Volume

- It's a network drive (i.e. not a physical drive)
  - It uses the network to communicate the instance, which means there might be a bit of latency
  - It can be detached from an EC2 instance and 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, you first need to snapshot it
- Have a provisioned capacity (size in GBs, and IOPS)
  - You get billed for all the provisioned capacity
  - You can increase the capacity of the drive over time

# EBS Volume - Example



# EBS – Delete on Termination attribute



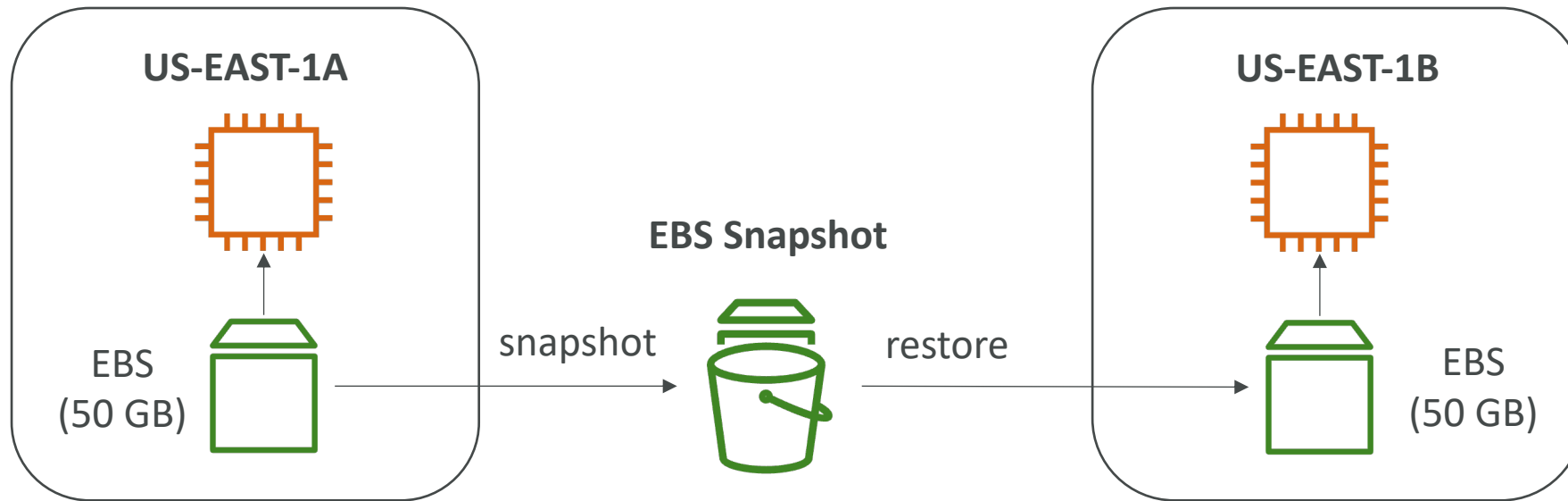
Volume Type ⓘ	Device ⓘ	Snapshot ⓘ	Size (GiB) ⓘ	Volume Type ⓘ	IOPS ⓘ	Throughput (MB/s) ⓘ	Delete on Termination ⓘ	Encryption ⓘ
Root	/dev/xvda	snap-09f18f682fd23a1b1	8	General Purpose SSD (gp2) ▼	100 / 3000	N/A	<input checked="" type="checkbox"/>	Not Encrypted ▼
EBS ▼	/dev/sdb ▼	Search (case-insensit	8	General Purpose SSD (gp2) ▼	100 / 3000	N/A	<input type="checkbox"/>	Not Encrypted ▼

Add New Volume

- 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 can be controlled by the AWS console / AWS CLI
- Use case: preserve root volume when instance is terminated

# EBS Snapshots

- Make a backup (snapshot) of your EBS volume at a point in time
- Not necessary to detach volume to do snapshot, but recommended
- Can copy snapshots across AZ or Region



# EBS Snapshots Features

- **EBS Snapshot Archive**

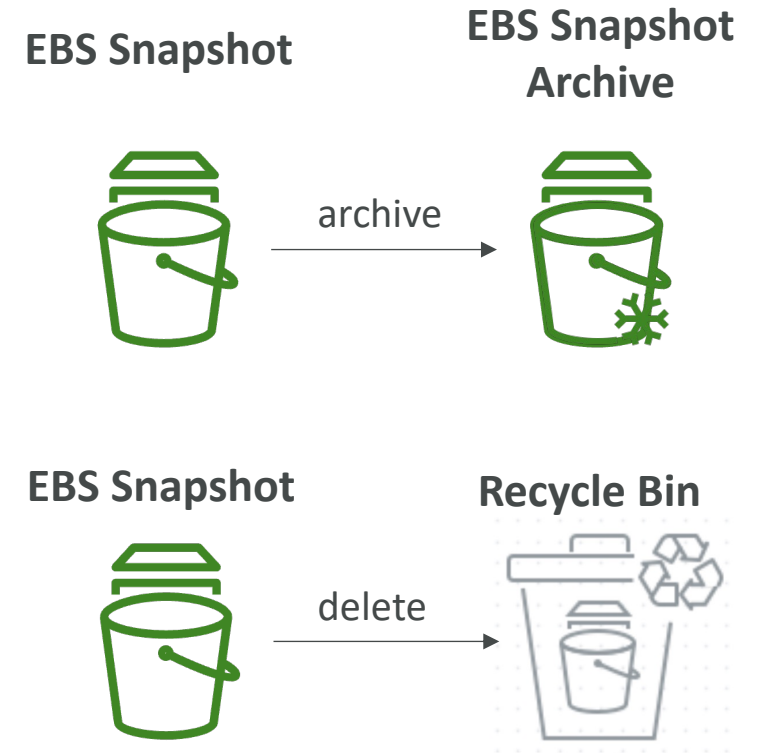
- Move a Snapshot to an "archive tier" that is 75% cheaper
- Takes within 24 to 72 hours for restoring the archive

- **Recycle Bin for EBS Snapshots**

- Setup rules to retain deleted snapshots so you can recover them after an accidental deletion
- Specify retention (from 1 day to 1 year)

- **Fast Snapshot Restore (FSR)**

- Force full initialization of snapshot to have no latency on the first use (\$\$\$)





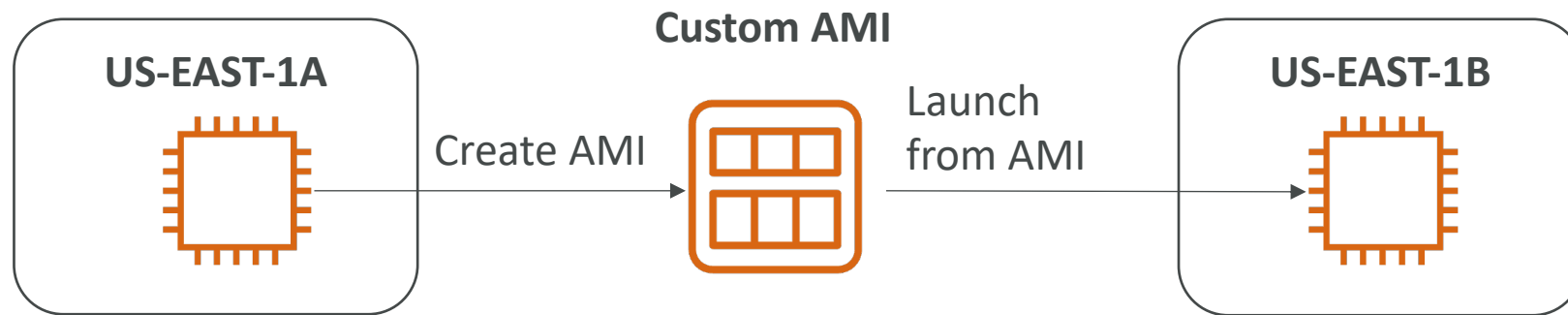
# AMI Overview

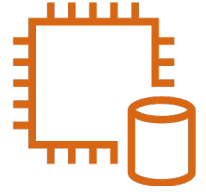
- AMI = Amazon Machine Image
- AMI are a **customization** of an EC2 instance
  - You add your own software, configuration, operating system, monitoring...
  - Faster boot / configuration time because all your software is pre-packaged
- AMI are built for a **specific region** (and can be copied across regions)
- You can launch EC2 instances from:
  - A Public AMI: AWS provided
  - Your own AMI: you make and maintain them yourself
  - An AWS Marketplace AMI: an AMI someone else made (and potentially sells)



# 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
- Better I/O performance
- EC2 Instance Store lose their storage if they're 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

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 Ops Per Sec)
- When in doubt always consult the AWS documentation – it's good!
- Only gp2/gp3 and io1/io2 Block Express can be used as boot volumes

# EBS Volume Types Use cases

## General Purpose SSD

- Cost effective storage, low-latency
- System boot volumes, Virtual desktops, Development and test environments
- 1 GiB - 16 TiB
- gp3:
  - Baseline of 3,000 IOPS and throughput of 125 MiB/s
  - Can increase IOPS up to 16,000 and throughput up to 1000 MiB/s independently
- gp2:
  - Small gp2 volumes can burst IOPS to 3,000
  - Size of the volume and IOPS are linked, max IOPS is 16,000
  - 3 IOPS per GB, means at 5,334 GB we are at the max IOPS

# EBS Volume Types Use cases

## Provisioned IOPS (PIOPS) SSD

- Critical business applications with sustained IOPS performance
- Or applications that need more than 16,000 IOPS
- Great for **databases workloads** (sensitive to storage perf and consistency)
- io1 (4 GiB - 16 TiB):
  - Max PIOPS: 64,000 for Nitro EC2 instances & 32,000 for other
  - Can increase PIOPS independently from storage size
- io2 Block Express (4 GiB – 64 TiB):
  - Sub-millisecond latency
  - Max PIOPS: 256,000 with an IOPS:GiB ratio of 1,000:1
- Supports EBS Multi-attach

# EBS Volume Types Use cases

## Hard Disk Drives (HDD)

- Cannot be a boot volume
- 125 GiB to 16 TiB
- Throughput Optimized HDD (st1)
  - Big Data, Data Warehouses, Log Processing
  - **Max throughput** 500 MiB/s – max IOPS 500
- Cold HDD (sc1):
  - For data that is infrequently accessed
  - Scenarios where lowest cost is important
  - **Max throughput** 250 MiB/s – max IOPS 250

# EBS – Volume Types Summary

	General Purpose SSD volumes		Provisioned IOPS SSD volumes	
Volume type	gp3	gp2	io2 Block Express <sup>3</sup>	io1
Durability	99.8% - 99.9% durability (0.1% - 0.2% annual failure rate)		99.999% durability (0.001% annual failure rate)	99.8% - 99.9% durability (0.1% - 0.2% annual failure rate)
Use cases	<ul style="list-style-type: none"> <li>Transactional workloads</li> <li>Virtual desktops</li> <li>Medium-sized, single-instance databases</li> <li>Low-latency interactive applications</li> <li>Boot volumes</li> <li>Development and test environments</li> </ul>		Workloads that require: <ul style="list-style-type: none"> <li>Sub-millisecond latency</li> <li>Sustained IOPS performance</li> <li>More than 64,000 IOPS or 1,000 MiB/s of throughput</li> </ul>	<ul style="list-style-type: none"> <li>Workloads that require sustained IOPS performance or more than 16,000 IOPS</li> <li>I/O-intensive database workloads</li> </ul>
Volume size	1 GiB - 16 TiB		4 GiB - 64 TiB <sup>4</sup>	4 GiB - 16 TiB
Max IOPS per volume (16 KiB I/O)	16,000		256,000 <sup>5</sup>	64,000
Max throughput per volume	1,000 MiB/s	250 MiB/s <sup>1</sup>	4,000 MiB/s	1,000 MiB/s <sup>2</sup>
Amazon EBS Multi-attach	Not supported		Supported	
NVMe reservations	Not supported		Supported	Not supported
Boot volume	Supported			

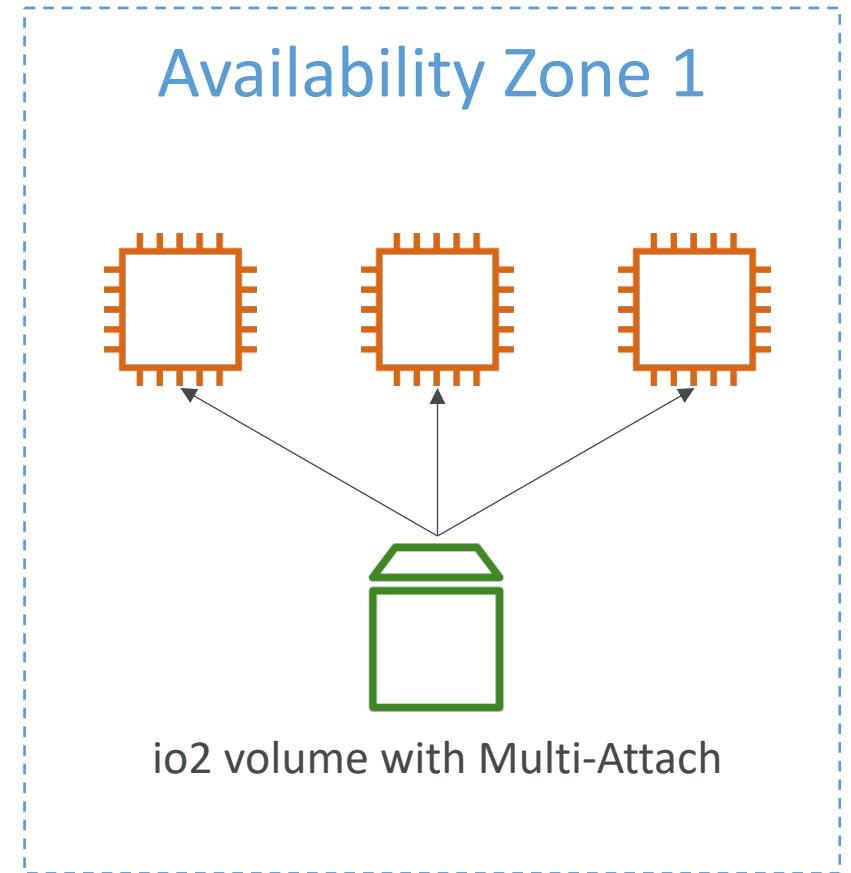
	Throughput Optimized HDD volumes	Cold HDD volumes
Volume type	st1	sc1
Durability	99.8% - 99.9% durability (0.1% - 0.2% annual failure rate)	
Use cases	<ul style="list-style-type: none"> <li>Big data</li> <li>Data warehouses</li> <li>Log processing</li> </ul>	<ul style="list-style-type: none"> <li>Throughput-oriented storage for data that is infrequently accessed</li> <li>Scenarios where the lowest storage cost is important</li> </ul>
Volume size	125 GiB - 16 TiB	
Max IOPS per volume (1 MiB I/O)	500	250
Max throughput per volume	500 MiB/s	250 MiB/s
Amazon EBS Multi-attach	Not supported	
Boot volume	Not supported	

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



# EBS Multi-Attach – io1/io2 family

- Attach the same EBS volume to multiple EC2 instances in the same AZ
- Each instance has full read & write permissions to the high-performance volume
- Use case:
  - Achieve **higher application availability** in clustered Linux applications (ex: Teradata)
  - Applications must manage concurrent write operations
- Up to 16 EC2 Instances at a time
- Must use a file system that's cluster-aware (not XFS, EXT4, etc...)



# EBS Encryption

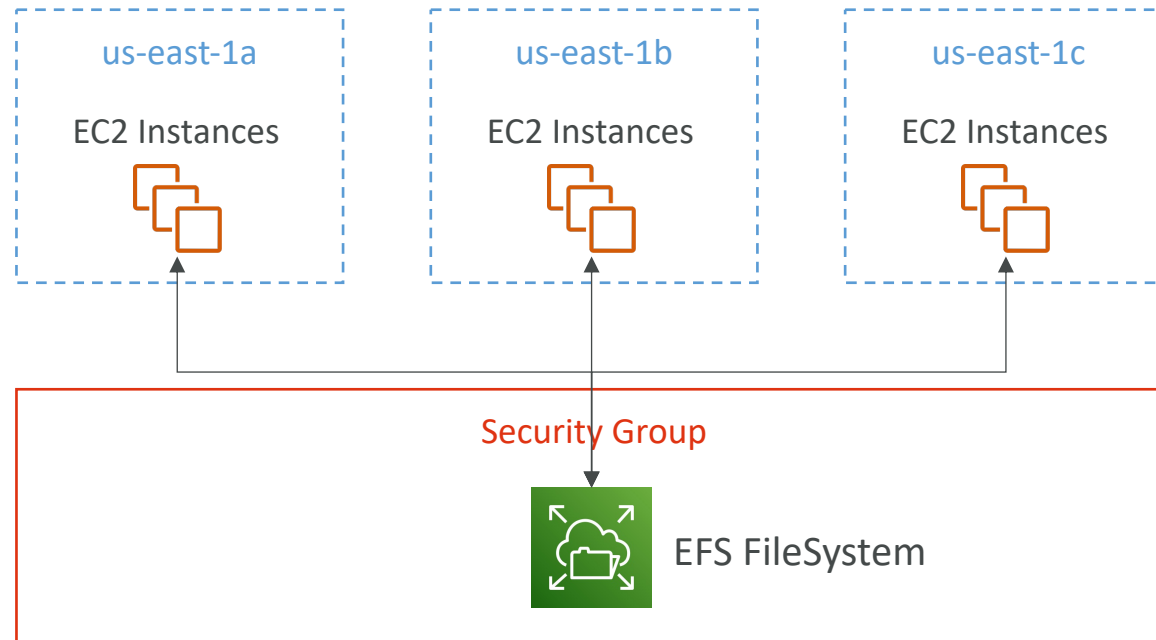
- When you create an encrypted EBS volume, you get the following:
  - Data at rest is encrypted inside the volume
  - All the data in flight moving between the instance and the volume is encrypted
  - All snapshots are encrypted
  - All volumes created from the snapshot
- Encryption and decryption are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

# Encryption: encrypt an unencrypted EBS volume

- Create an EBS snapshot of the volume
- Encrypt the EBS snapshot ( using copy )
- Create new ebs volume from the snapshot ( the volume will also be encrypted )
- Now you can attach the encrypted volume to the original instance

# Amazon EFS – Elastic File System

- Managed NFS (network file system) that can be mounted on many EC2
- EFS works with EC2 instances in multi-AZ
- Highly available, scalable, expensive (3x gp2), pay per use



# Amazon EFS – Elastic File System

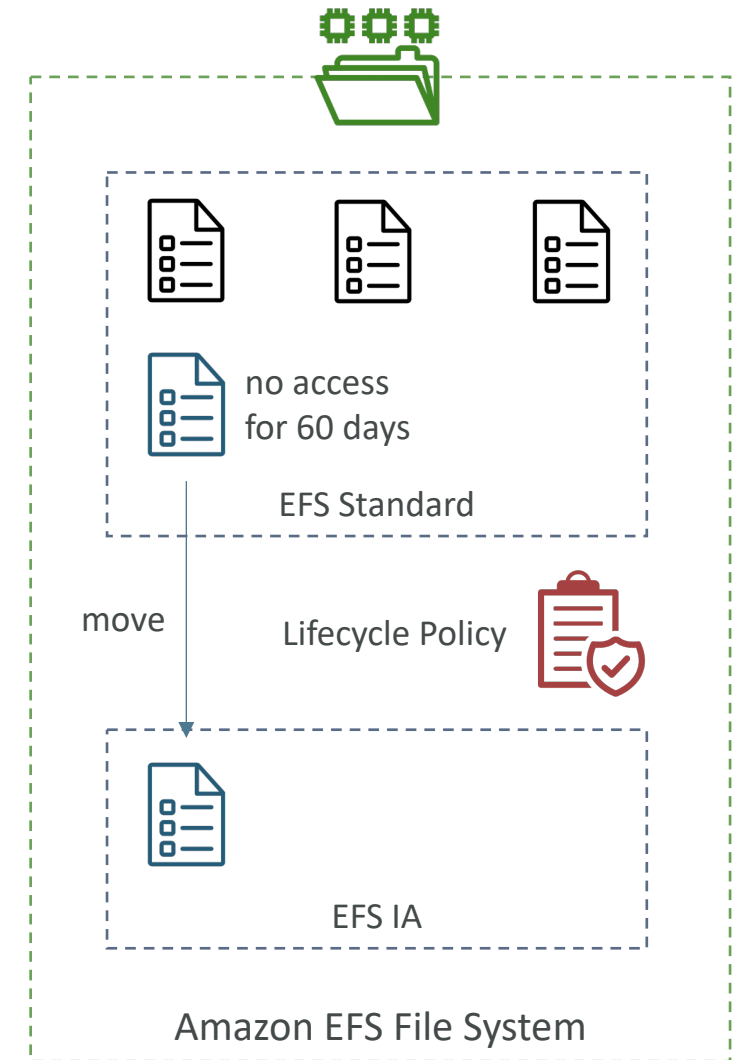
- Use cases: content management, web serving, data sharing, Wordpress
- Uses NFSv4.1 protocol
- Uses security group to control access to EFS
- **Compatible with Linux based AMI (not Windows)**
- Encryption at rest using KMS
- POSIX file system (~Linux) that has a standard file API
- File system scales automatically, pay-per-use, no capacity planning!

# EFS – Performance & Storage Classes

- **EFS Scale**
  - 1000s of concurrent NFS clients, 10 GB+ /s throughput
  - Grow to Petabyte-scale network file system, automatically
- **Performance Mode (set at EFS creation time)**
  - **General Purpose (default)** – latency-sensitive use cases (web server, CMS, etc...)
  - **Max I/O** – higher latency, throughput, highly parallel (big data, media processing)
- **Throughput Mode**
  - **Bursting** – 1 TB = 50MiB/s + burst of up to 100MiB/s
  - **Provisioned** – set your throughput regardless of storage size, ex: 1 GiB/s for 1 TB storage
  - **Elastic** – automatically scales throughput up or down based on your workloads
    - Up to 3GiB/s for reads and 1 GiB/s for writes
    - Used for unpredictable workloads

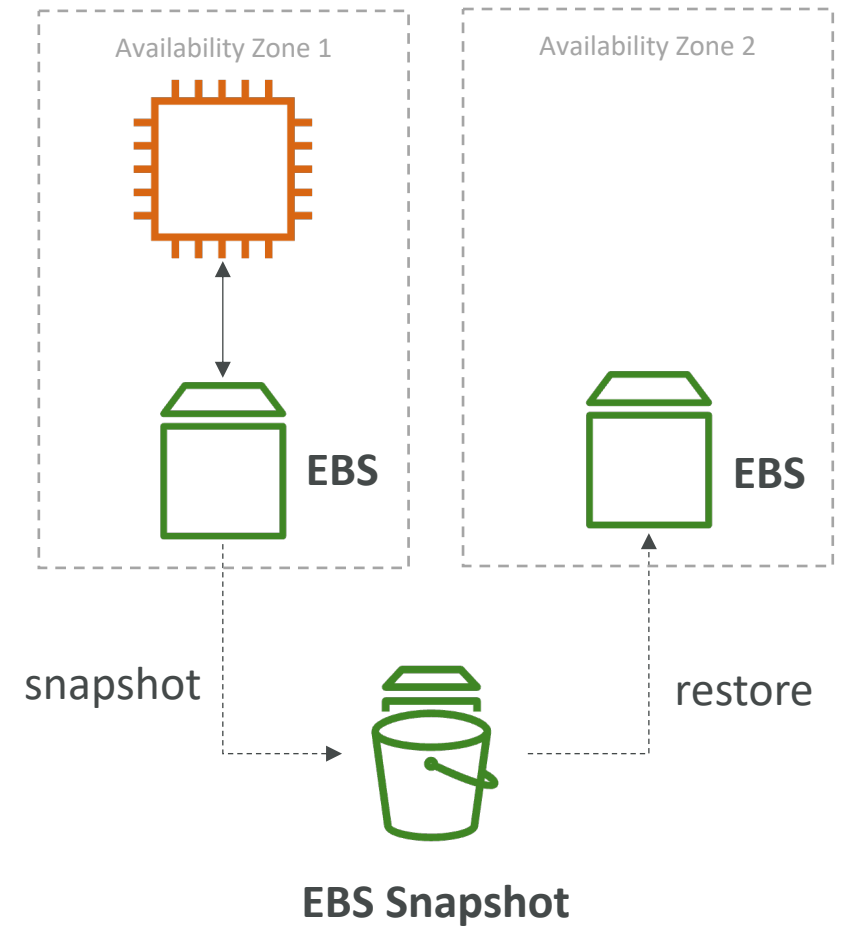
# EFS – Storage Classes

- Storage Tiers (lifecycle management feature – move file after N days)
  - **Standard**: for frequently accessed files
  - **Infrequent access (EFS-IA)**: cost to retrieve files, lower price to store.
  - **Archive**: rarely accessed data (few times each year), 50% cheaper
  - Implement **lifecycle policies** to move files between storage tiers
- **Availability and durability**
  - Standard: Multi-AZ, great for prod
  - One Zone: One AZ, great for dev, backup enabled by default, compatible with IA (EFS One Zone-IA)
- Over 90% in cost savings



# EBS vs EFS – Elastic Block Storage

- EBS volumes...
  - one instance (except multi-attach io1/io2)
  - are locked at the Availability Zone (AZ) level
  - gp2: IO increases if the disk size increases
  - gp3 & io1: can increase IO independently
- To migrate an EBS volume across AZ
  - Take a snapshot
  - Restore the snapshot to another AZ
  - EBS backups use IO and you shouldn't run them while your application is handling a lot of traffic
- Root EBS Volumes of instances get terminated by default if the EC2 instance gets terminated. (you can disable that)





# EBS vs EFS – Elastic File System

- Mounting 100s of instances across AZ
- EFS share website files (WordPress)
- Only for Linux Instances (POSIX)
- EFS has a higher price point than EBS
- Can leverage Storage Tiers for cost savings
- Remember: EFS vs EBS vs Instance Store

