

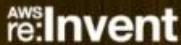
CMP310

AWS re:INVENT

Deep Dive on Amazon EBS

Jody Gibney, Sr. Manager, Product Management
Marc Olson, Principal Software Engineer

November 30, 2017



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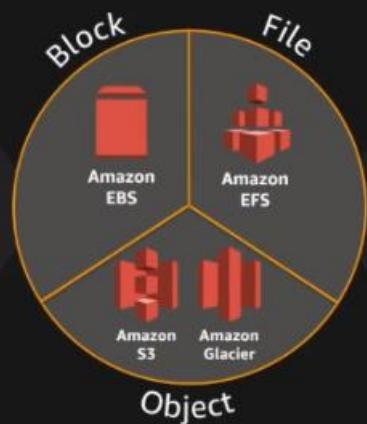


In this popular session, discover how Amazon EBS can take your application deployments on Amazon EC2 to the next level. Learn about Amazon EBS features and benefits, how to identify applications that are appropriate for use with Amazon EBS, best practices, and details about its performance and volume types. The target audience is storage administrators, application developers, applications owners, and anyone who wants to understand how to optimize performance for Amazon EC2 using the power of Amazon EBS.

Complete set of data building blocks

Data movement

- AWS Storage Gateway Family
- Amazon Kinesis Video Streams
- Amazon Kinesis Data Streams
- Amazon EFS File Sync
- Amazon S3 Transfer Acceleration
- AWS Direct Connect
- Storage Partners
-
- AWS Snow family



Data security and management

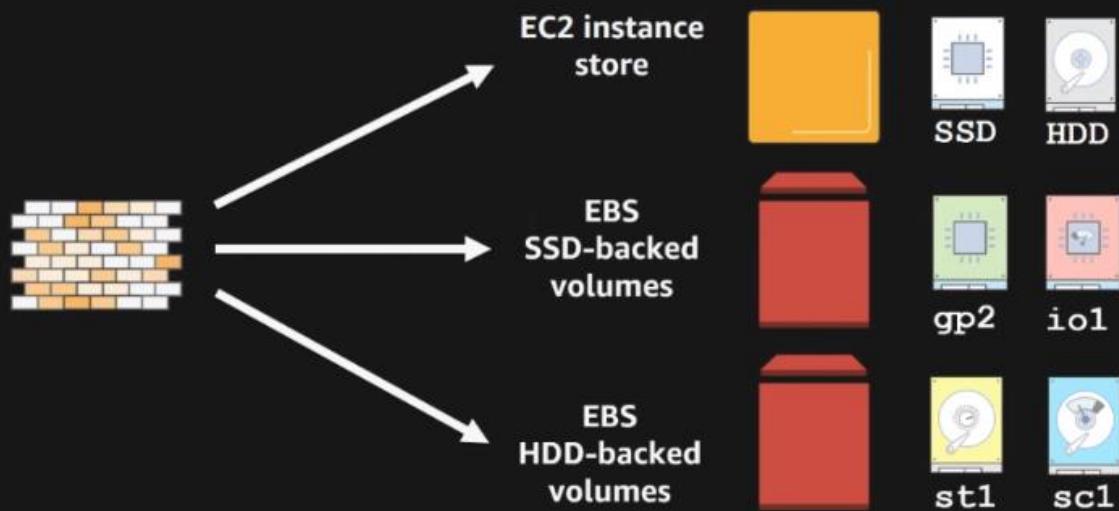
- Amazon Macie
- AWS QuickSight
- AWS Lambda
- AWS CloudFormation
- AWS CloudTrail
- AWS CloudWatch
- AWS IAM
- AWS KMS



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AWS block storage offerings

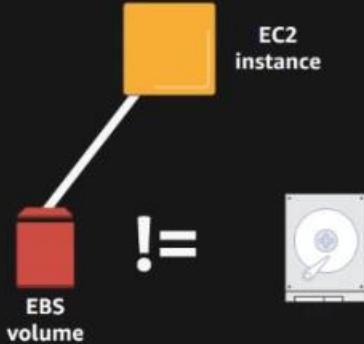


What is Amazon EC2 instance store?



- Local to instance
- Non-persistent data store
- Data not replicated (by default)
- No snapshot support
- SSD or HDD

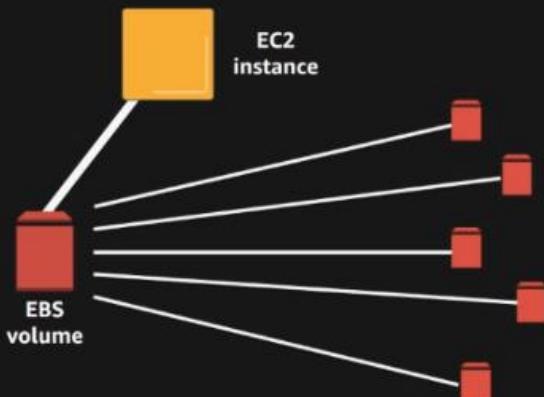
What is EBS?



- Block storage as a service
- Create, attach volumes through an API
- Service accessed over the network

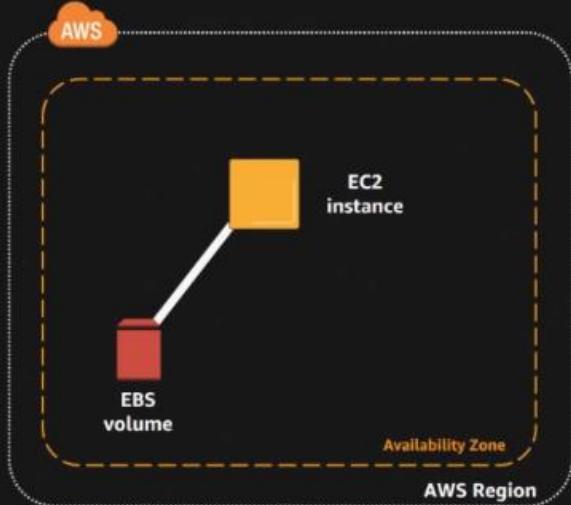
EBS is block storage as a service, with an API call, you can configure an amount of volume blocks with specific performance characteristics and attach them to your EC2 instance.

What is EBS?



EBS is a massively distributed system and an EBS volume is a logical volume that is comprised of blocks that are spread across many different physical devices.

What is EBS?



- Volumes persist independent of EC2
- Select storage and compute based on your workload
- Detach and attach between instances within the same Availability Zone

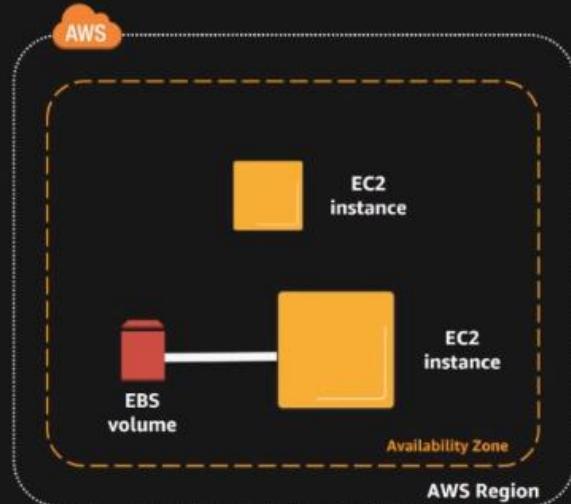
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You EBS volume exists in a single AZ and the EBS volumes are entirely independent of EC2, the EBS volume is persistent.

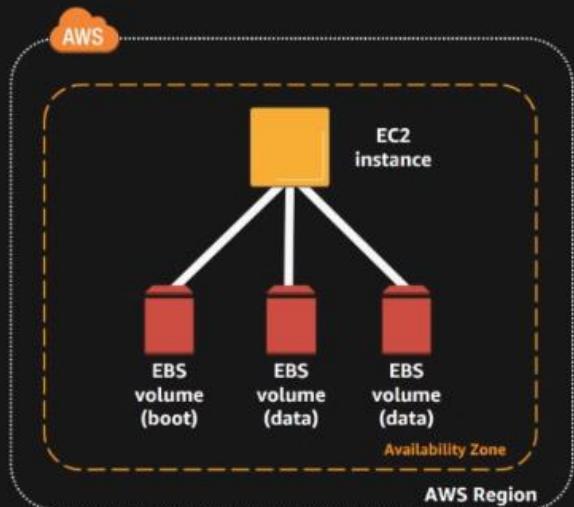
What is EBS?



- Volumes persist independent of EC2
- Select storage and compute based on your workload
- Detach and attach between instances within the same Availability Zone

You can detach and attach your EBS volume to another EC2 instance within the same AZ if needed,

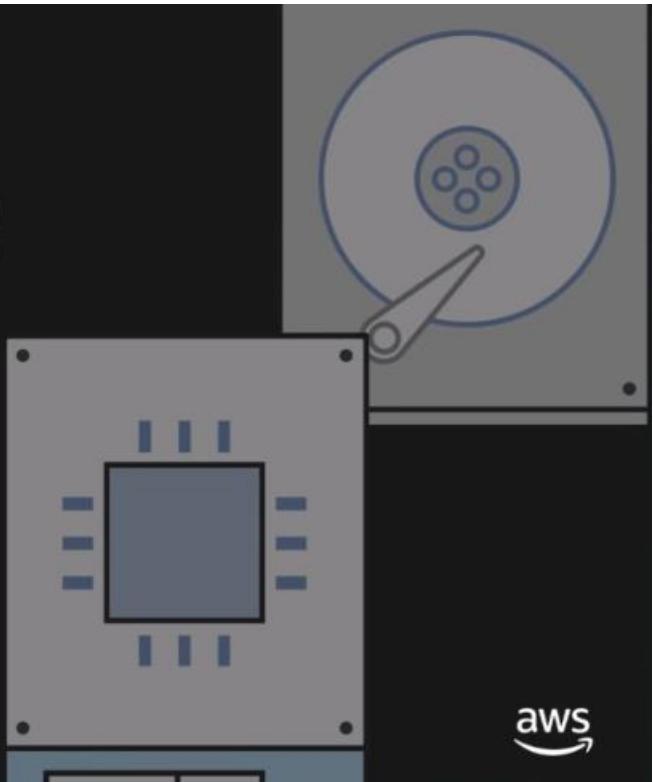
What is EBS?



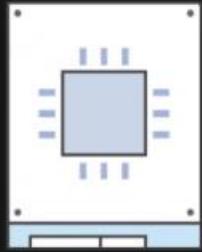
- Volumes attach to one instance
- Many volumes can attach to an instance
- Separate boot and data volumes

You can attach an EBS volume to only one EC2 instance at a time, but you can attach multiple EBS volumes to a single EC2 instance. You should keep your boot volume small and move your data volumes around as necessary

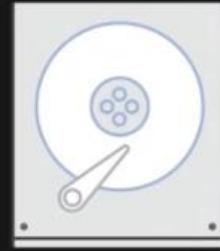
EBS volume types



EBS volume types



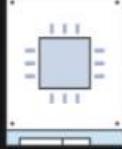
Solid-state drives (SSD)



Hard disk drives (HDD)

SSD backed EBS volumes are flash based, meaning that you can seek data from any point in the disk and this makes them suitable for tasks doing random I/O. HDD backed EBS volumes are disk based and require that the head be moved to the data position, meaning that they are not suitable for random I/O tasks. But once you move the head for a HDD backed EBS volume to the disk data position, you can get great throughput performance for sequential I/O that are low in price point.

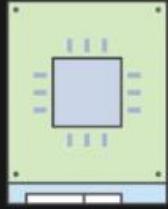
EBS volume types



SSD



HDD



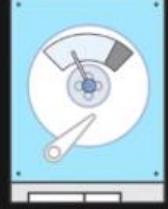
gp2
General Purpose
SSD



io1
Provisioned IOPS
SSD



st1
Throughput Optimized HDD



sc1
Cold HDD

Choosing an EBS volume type

What is more important to your workload?



or



Throughput?

Choosing an EBS volume type

IOPS is more important	
> 80,000	≤ 80,000

Latency?

< 1 ms Single-digit ms

Which is more important?

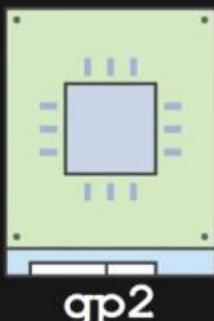
Cost Performance

i3



gp2

EBS volume types: General Purpose SSD



General Purpose SSD

Baseline: 100 to 10,000 IOPS; 3 IOPS per GiB

Burst: 3,000 IOPS (for volumes up to 1,000 GiB)

Throughput: Up to 160 MiB/s

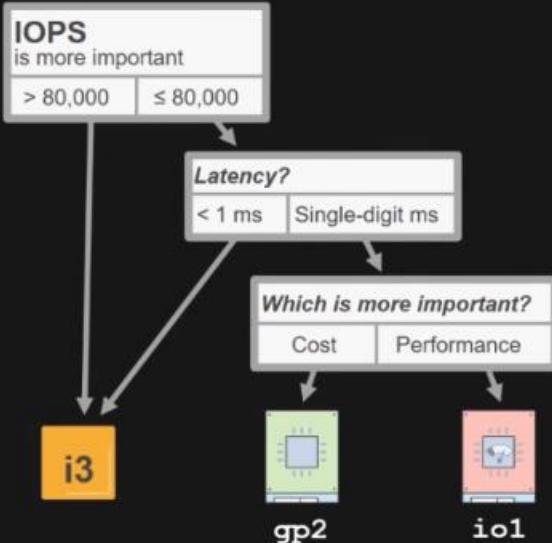
Latency: Single-digit ms

Capacity: 1 GiB to 16 TiB

Great for boot volumes, low-latency applications, and bursty databases

The gp2 volume works for almost any workload, it is general purpose.

Choosing an EBS volume type



EBS volume types: Provisioned IOPS



io1

Provisioned IOPS

Baseline: 100 to 20,000 IOPS

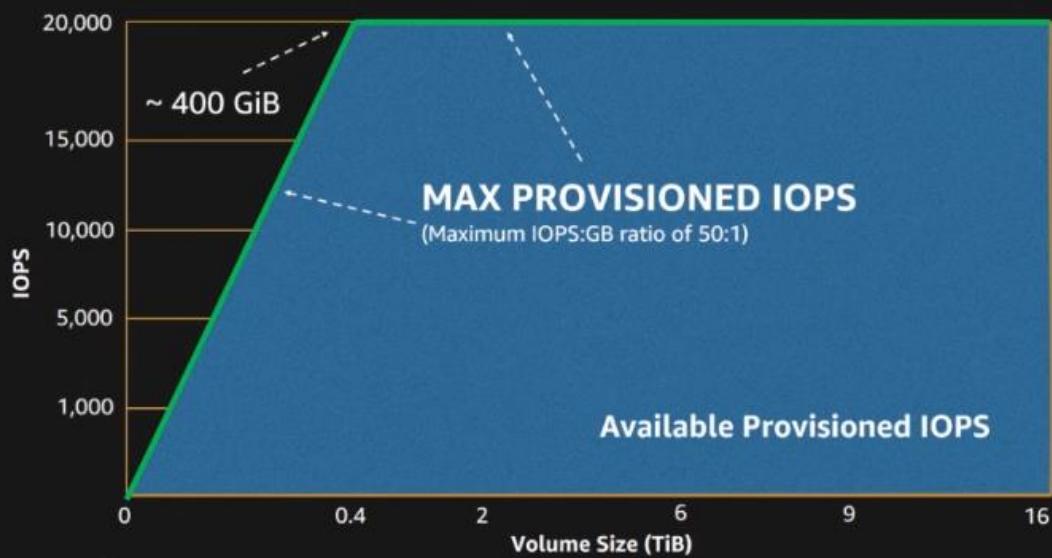
Throughput: Up to 320 MiB/s

Latency: Single-digit ms

Capacity: 4 GiB to 16 TiB

Ideal for critical applications and databases with sustained IOPS

Scaling Provisioned IOPS SSD (io1)

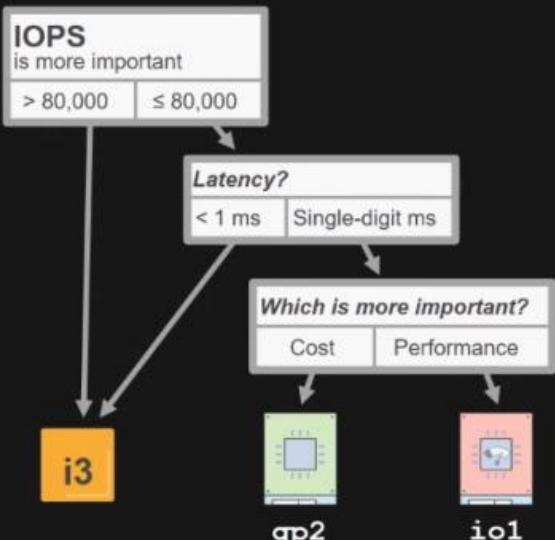


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Choosing an EBS volume type

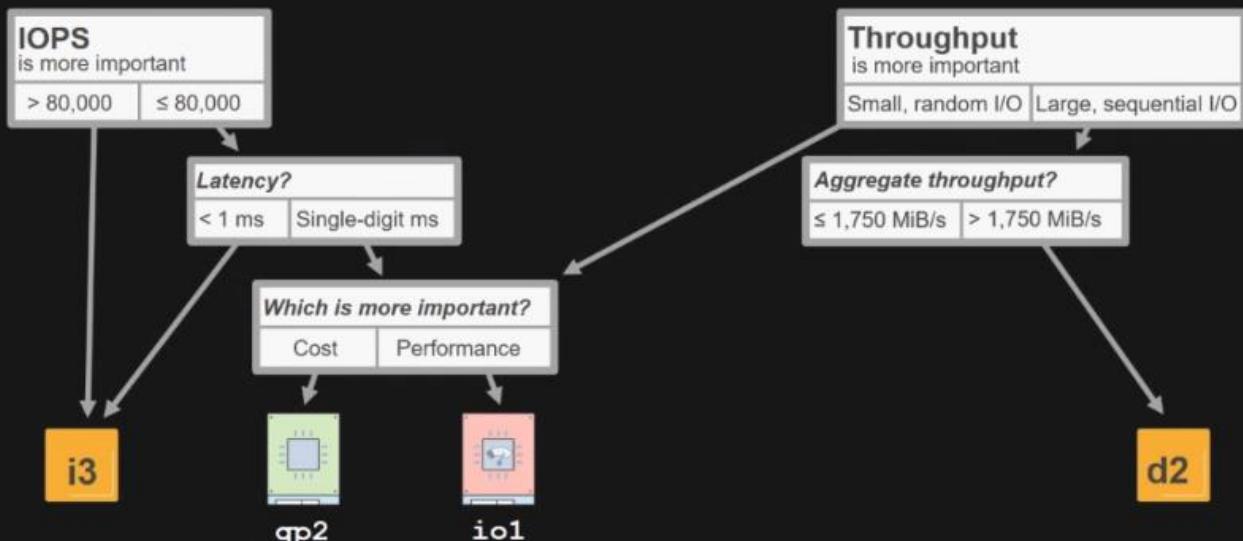


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Choosing an EBS volume type

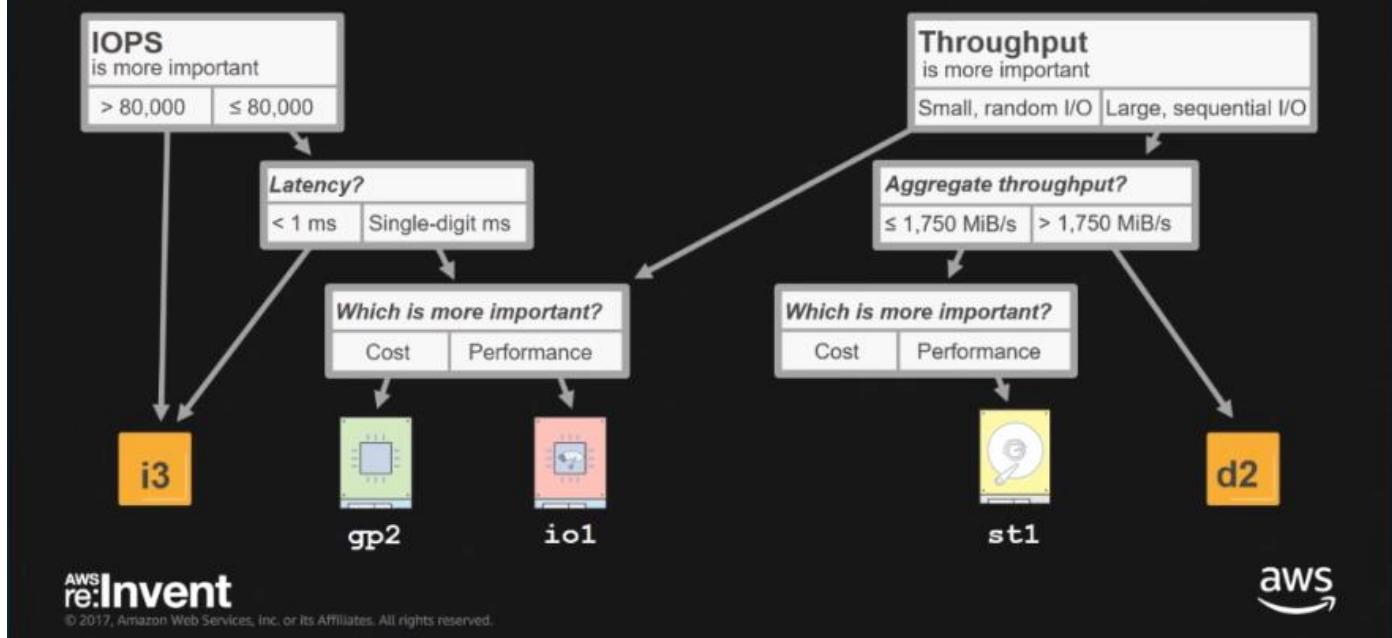


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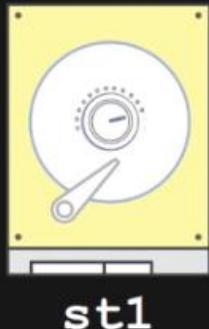
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Choosing an EBS volume type



EBS volume types: Throughput Provisioned



Baseline: 40 MiB/s per TiB up to 500 MiB/s

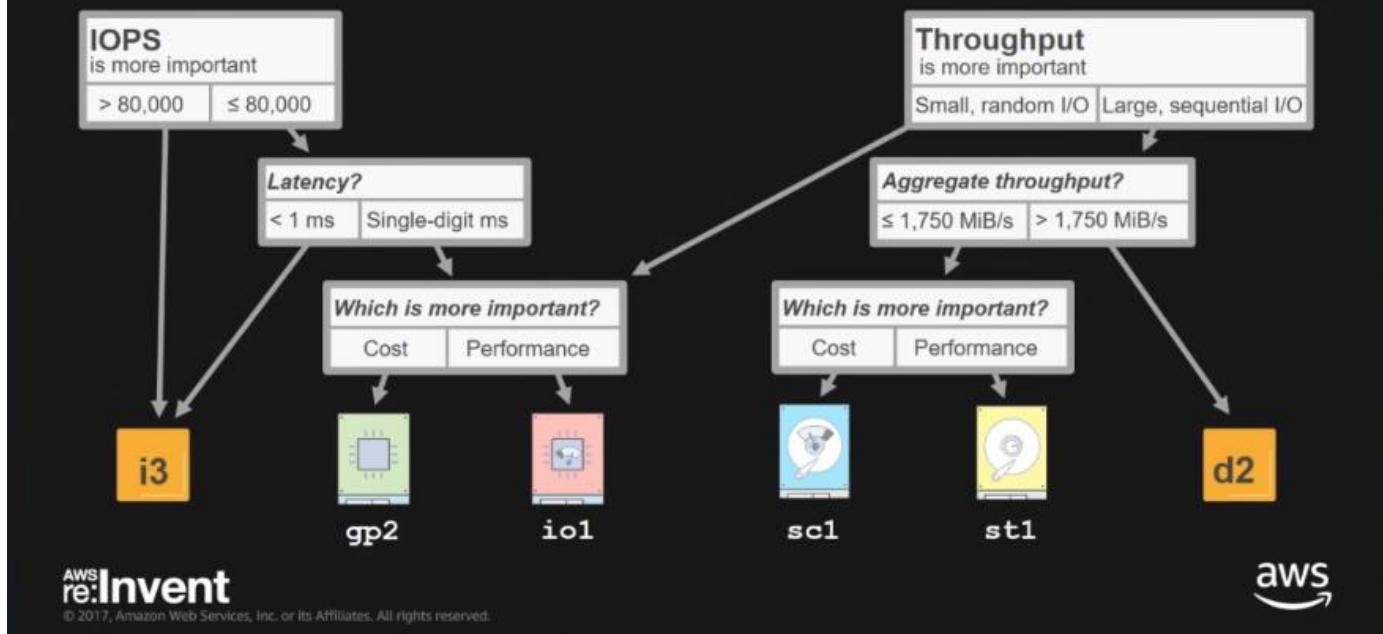
Burst: 250 MiB/s per TiB up to 500 MiB/s

Capacity: 500 GiB to 16 TiB

Ideal for large-block, high-throughput sequential workloads

This is great for big data workloads like Hadoop, MapReduce, Splunk, etc

Choosing an EBS volume type

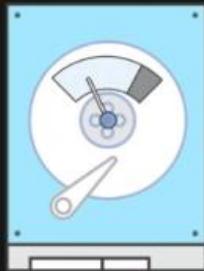


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EBS volume types: Throughput Provisioned



sc1

Cold HDD

Baseline: 12 MiB/s per TB up to 192 MiB/s

Burst: 80 MiB/s per TB up to 250 MiB/s

Capacity: 500 GiB to 16 TiB

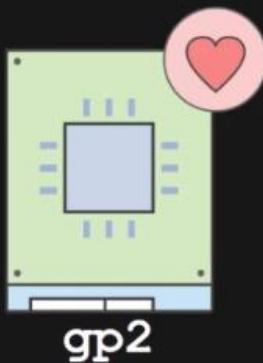
Ideal for sequential throughput workloads, such as logging and backup

Choosing an EBS volume type

**Don't know
your workload
yet?**



EBS volume types: General Purpose SSD



General Purpose SSD

Baseline: 100 to 10,000 IOPS; 3 IOPS per GiB

Burst: 3,000 IOPS (for volumes up to 1,000 GiB)

Throughput: Up to 160 MiB/s

Latency: Single-digit ms

Capacity: 1 GiB to 16 TiB

Great for boot volumes, low-latency applications, and bursty databases

Hybrid volume use cases

Case study:

Running Cassandra on Amazon EBS

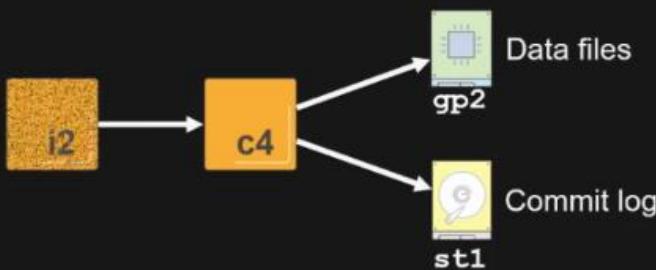


Customers usually mix instance types with different EBS volumes when trying to maximize storage and performance for their applications. Librato is a cloud metrics monitoring company and CrowdStrike provides enterprise threat detection. Both of these customers are running their petabyte-scale Cassandra clusters on i2 instances

Hybrid volume use cases

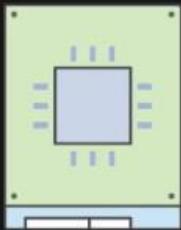
Case study:

Running Cassandra on Amazon EBS



They moved to c4 instances and put their hot data files on gp2 volumes and they put the majority sequential Cassandra commit log on st1 volumes to get the best performance and low cost

I/O Provisioned Volumes



gp2

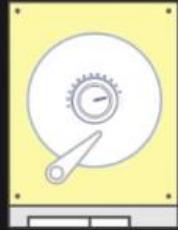
\$0.10 per GiB



io1

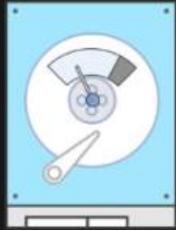
\$0.125 per GiB
\$0.065 per PIOPS

Throughput Provisioned Volumes



st1

\$0.045 per GiB



sc1

\$0.025 per GiB

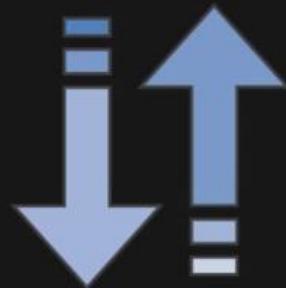
* All prices are per month, prorated to the second, and from the us-west-2 Region as of November 2017

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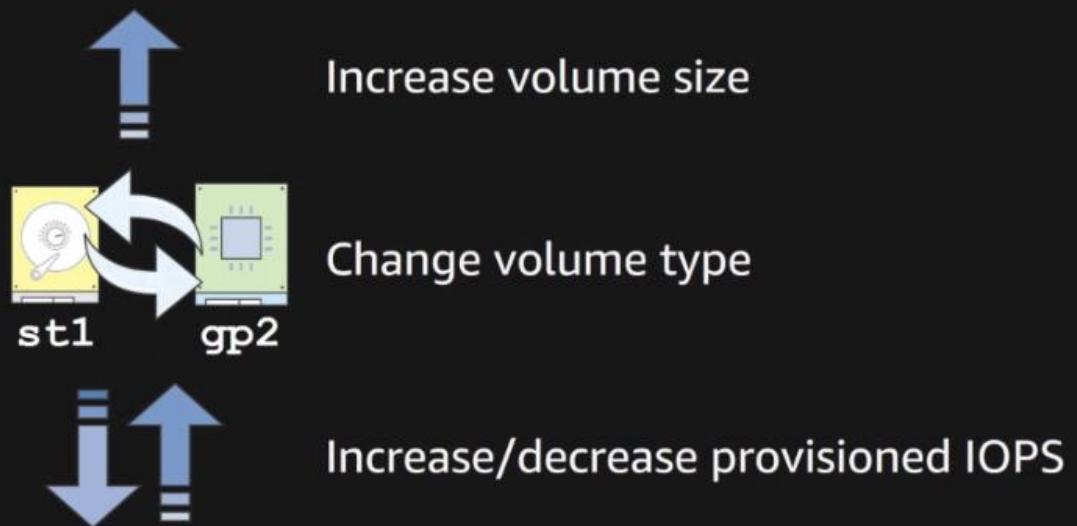
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EBS Elastic Volumes



Elastic Volumes: Features

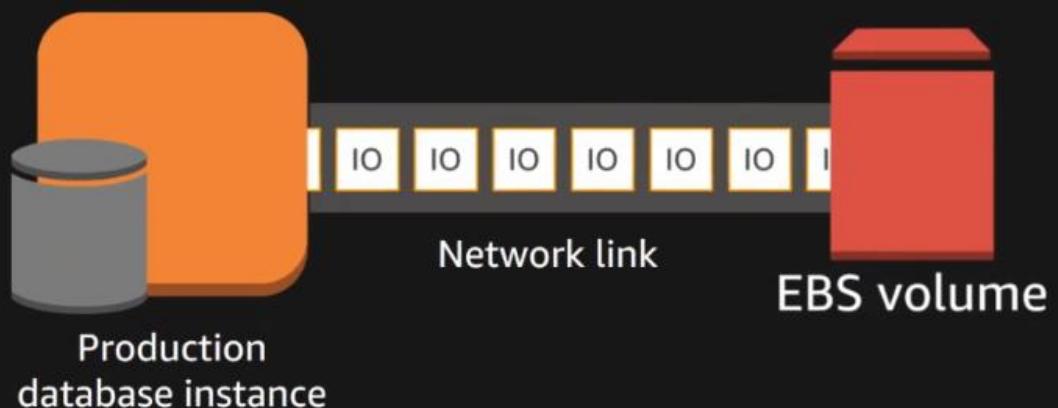


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Elastic Volumes: Overview



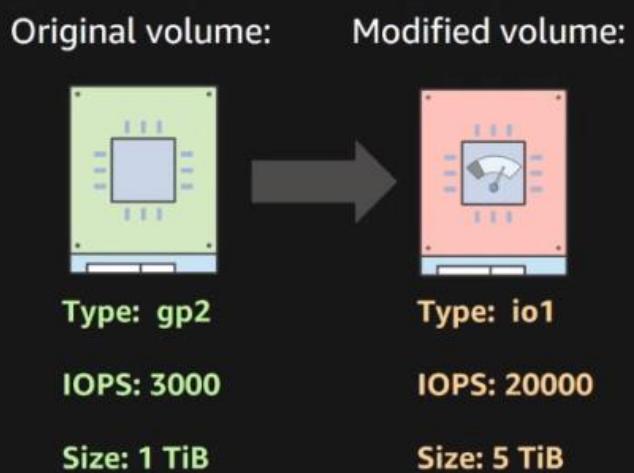
You can do this while your apps are running and actively driving data to your EBS volume. There is no need for maintenance window or downtime. You also no longer have to over provision your volume

How to modify

1. Snapshot volume
2. Modify volume
3. Monitor modification
4. Extend filesystem (if necessary)

Step 1: Modify volume

```
aws ec2 modify-volume  
--volume-id vol-05c33eec9820afc20  
--size 5000  
--volume-type io1  
--iops 20000
```



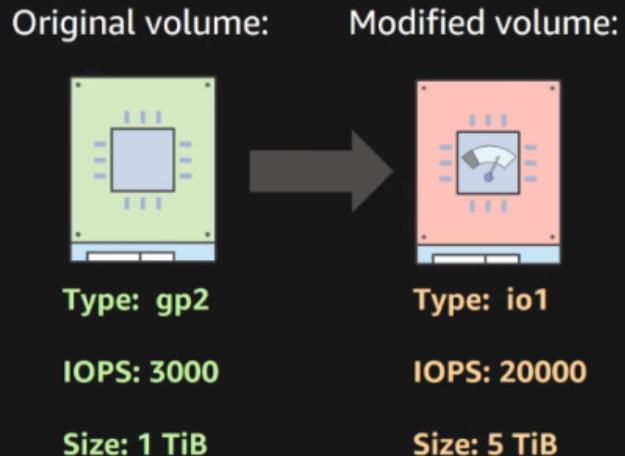
You can modify your volume using the `$ aws ec2 modify-volume ...` command, here we are going from a 1TB gp2 volume to a 5TB io1 volume with 20000 IOPS.

Step 2: Monitor volume

```
aws ec2 describe-volumes-modifications  
--volume-id vol-05c33eec9820afc20  
{  
  "VolumesModifications": [  
    {  
      "TargetSize": 5000,  
      "TargetVolumeType": "io1",  
      "ModificationState": "optimizing",  
      "VolumeId": "vol-05c33eec9820afc20",  
      "TargetIops": 20000,  
      "StartTime": "2017-03-25T20:32:31.717Z",  
      "Progress": 99,  
      "OriginalVolumeType": "gp2",  
      "OriginalIops": 3000,  
      "OriginalSize": 1000  
    }  
  ]  
}
```

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You can then use the `$ aws ec2 describe-volumes-modifications` command to see the state of the volume change and what state it is in

Step 2: Monitor volume (EC2 console)

The screenshot shows the AWS EC2 Dashboard with the 'VOLUMES' section selected. In the center, a 'Create Volume' button is visible above a table listing volumes. One row in the table is highlighted with a red box, showing a volume with ID 'vol-05c33eec9820afc20'. The 'State' column for this volume displays 'available - modifying (0%)'. Below the table, detailed information about the volume is shown, including its ID, size, creation date, and various configuration settings like volume type (io1) and IOPS (20000). The 'Monitoring' tab is selected at the bottom of the volume details panel.

You will see the state in **modifying** as above, then it moves to **optimizing** state as below

Step 2: Monitor volume (EC2 console)

The screenshot shows the AWS EC2 Dashboard with the 'Volumes' section selected. A new volume, 'vol-05c33ee...', is listed with the following details:

Name	Volume ID	Size	Volume Type	IOPS	Status	Alarm Status	Attachments
vol-05c33ee...	vol-05c33ee...	5000 GiB	io1	20000	available - optimizing (99%)	None	None

Below the table, the volume's description is shown:

Volume ID: vol-05c33eeec9820afc20	Created: March 25, 2017 at 3:19:20 PM UTC-5	State: available - optimizing (99%)	Attachment information: Volume type: io1, Product codes: -, IOPS: 20000	Alarm status: None	Snapshot: -	Availability Zone: us-west-1a	Encrypted: Not Encrypted	KMS Key ID: KMS Key Aliases: KMS Key ARN:
-----------------------------------	---	-------------------------------------	---	--------------------	-------------	-------------------------------	--------------------------	---

Once you are in the **optimizing** state you have the additional provisioned volume and you can go ahead and resize your file system

Step 3: Extending the filesystem (Linux)

- Determine your file system
- Compare block device size to file system disk usage
- Extend the file system (if needed)

Note: if the drive is partitioned, first grow the partitions

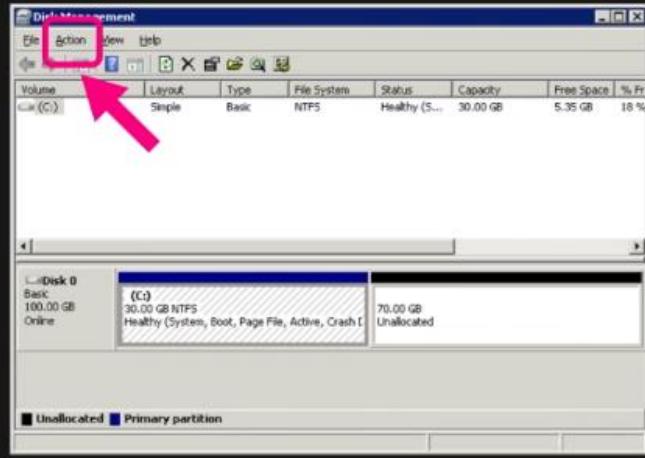
```
[ec2-user ~]$ sudo file -s /dev/xvd*
/dev/xvda1: Linux rev 1.0 ext4 filesystem data ...
/dev/xvdf: SGI XFS filesystem data ...
```

```
[ec2-user ~]$ lsblk
[ec2-user ~]$ df -h
```

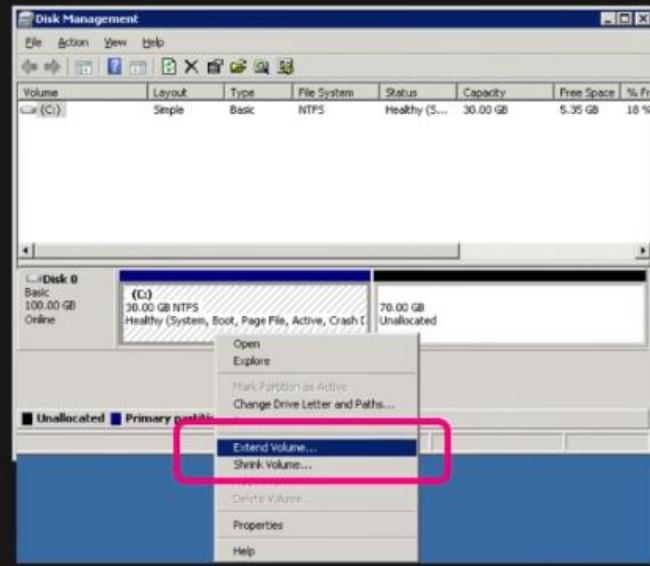
EXT:
[ec2-user ~]\$ sudo resize2fs **device_name**

XFS:
[ec2-user ~]\$ sudo xfs_growfs -d **mount_point**

Step 3: Extending the filesystem (Windows)



Step 3: Extending the filesystem (Windows)



Step 3: Extending the filesystem (Windows)



Resize partition with Powershell:

<https://docs.microsoft.com/en-us/powershell/module/storage/resize-partition?view=win10-ps>

Volume modification tips

- Modification must fit within volume specs (**1 GiB gp2 != 1 GiB st1**)
- Can modify volumes once every 6 hours
- Current generation instances **do not** need a stop/start or attach/detach
- Volumes created before 11/1/2016 **require** a stop/start or attach/detach

Elastic Volumes: Automation ideas



Elastic Volumes



Amazon CloudWatch



AWS Lambda

Elastic Volumes: Automation Ideas

Right-sizing:

- Publish a “**free space**” metric to CloudWatch and use Lambda + EC2 Systems Manager to **resize** the volume and the filesystem
- Use a CloudWatch alarm to watch for a volume that is running at or near its **IOPS limit** or exhausting **burst balance**
- Initiate workflow to provision additional IOPS



Amazon CloudWatch

<https://github.com/awslabs/aws-elastic-volumes>

This can publish a custom CloudWatch metric that shows the amount of free space on your OS, then using lambda and the EC2 Systems Manager to extend the volume and grow the filesystem

EBS deep dive



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How do volumes attach?

Once you create an EBS volume, you need to attach it to an EC2 instance

EBS volume attachment

API

AttachVolume

CLI

```
aws ec2 attach-volume --instance-id i-0cda3bbe40c6ba495  
--volume-id vol-01324f611e2463981 --device /dev/xvdf
```

Console



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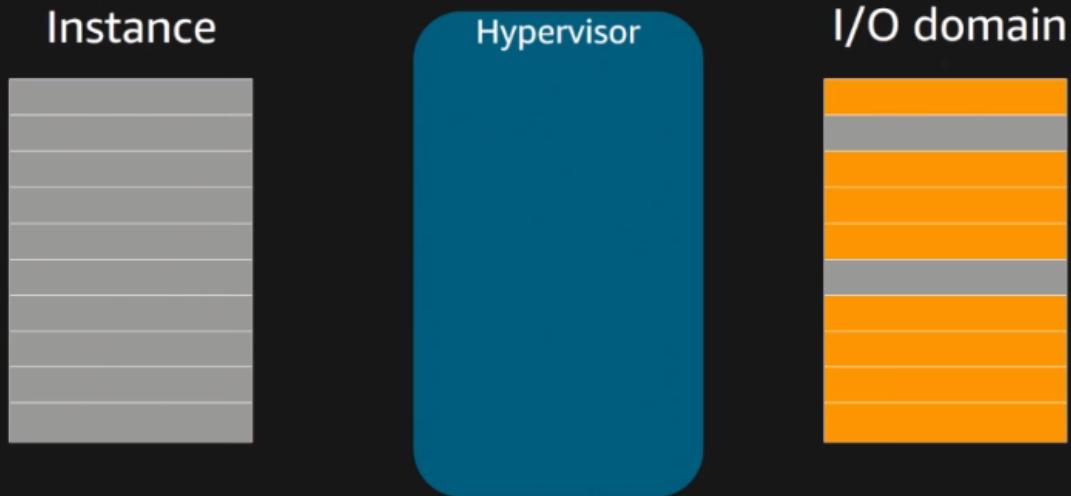
You can use the `$ aws ec2 attach-volume - -instance-id $instance_id - -volume-id $volume_id - -device /dev/xvdf` command. The mount point specified above is /dev/xvdf, this will show up on Linux and windows maps this to a busId

EBS volume attachment: Xen

```
[ec2-user@ip-10-0-69-96 ~]$ lsblk  
NAME   MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT  
xvda    202:0    0    8G  0 disk  
└─xvda1 202:1    0    8G  0 part /  
xvdf    202:80   0    1G  0 disk
```

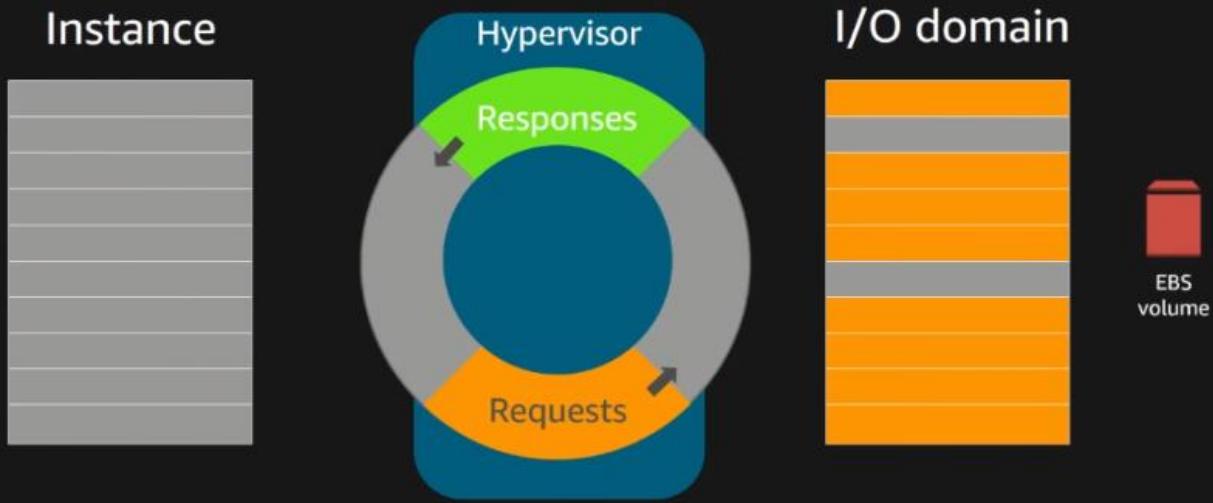
In Linux and Xen, you do a `$ lsblk` command as above to see the blocks attached to your EC2 instance.

A day in the life of an I/O: Xen



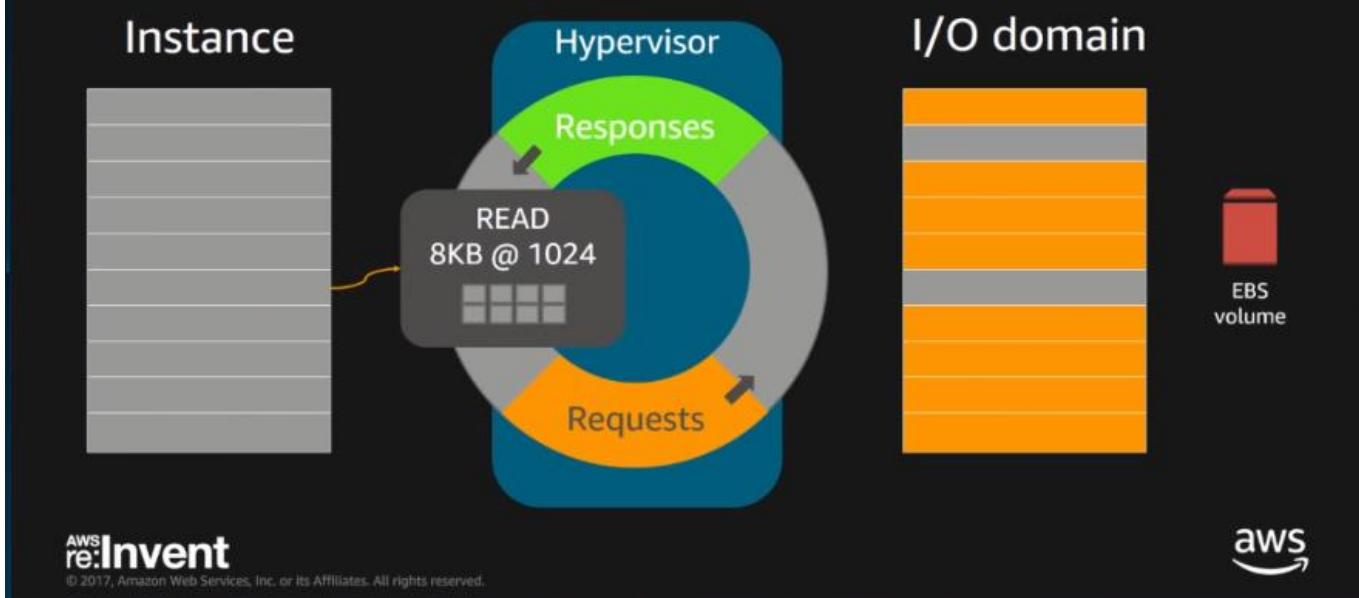
Above is what actually happening behind the scenes. Each EC2 instance is on its own hypervisor is associated with an I/O domain. This I/O domain does not have access to your instance memory, you instance also does not have access to the EBS volume.

A day in the life of an I/O: Xen

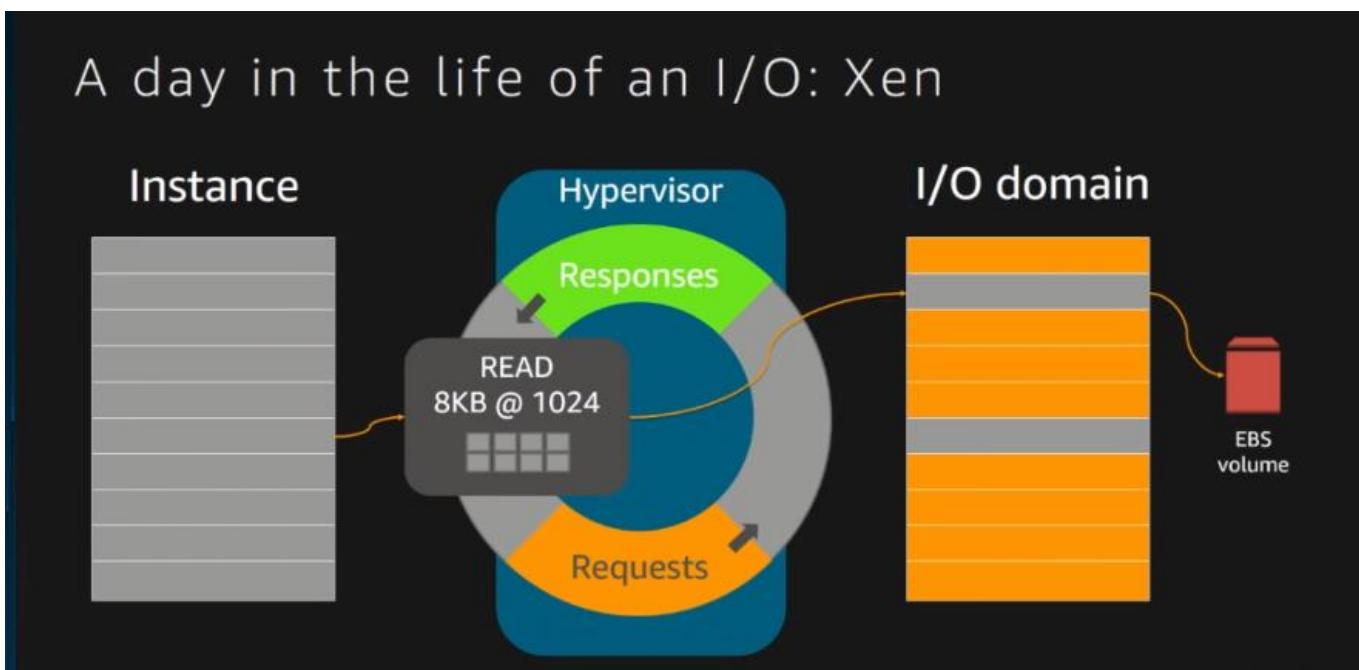


When you attach a volume, what happens is that the volume is attached to the I/O domain, a shared memory segment is then set up that acts as a queue for I/O requests between your instance and EBS. There are a couple of more queues in there that we are not interested in here.

A day in the life of an I/O: Xen



When your application wants to do a I/O it will submit a system call to the kernel (Linux or Windows), this gets put on the queue and notifies the I/O domain to wake up



The I/O domain wakes up and puts the request on another queue and sends it off to EBS. The response comes back from EBS and goes the other way.

EBS volume attachment: Nitro Hypervisor

```
[ec2-user@ip-10-0-12-183 ~]$ lsblk
NAME      MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
nvme0n1    259:1    0   1G  0 disk
nvme0n1    259:0    0   8G  0 disk
└─nvme0n1p1 259:2    0   8G  0 part /
└─nvme0n1p128 259:3   0   1M  0 part

[ec2-user@ip-10-0-12-183 ~]$ sudo nvme id-ctrl -v /dev/nvme0n1 | egrep "mn|sn|^00[01]0"
sn      : vol01324f611e2463981
mn      : Amazon Elastic Block Store
0000: 2f 64 65 76 2f 78 76 64 66 20 20 20 20 20 20 20 "/dev/xvdf...."
0010: 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 "....."
```

EBS volume attachment: Nitro Hypervisor

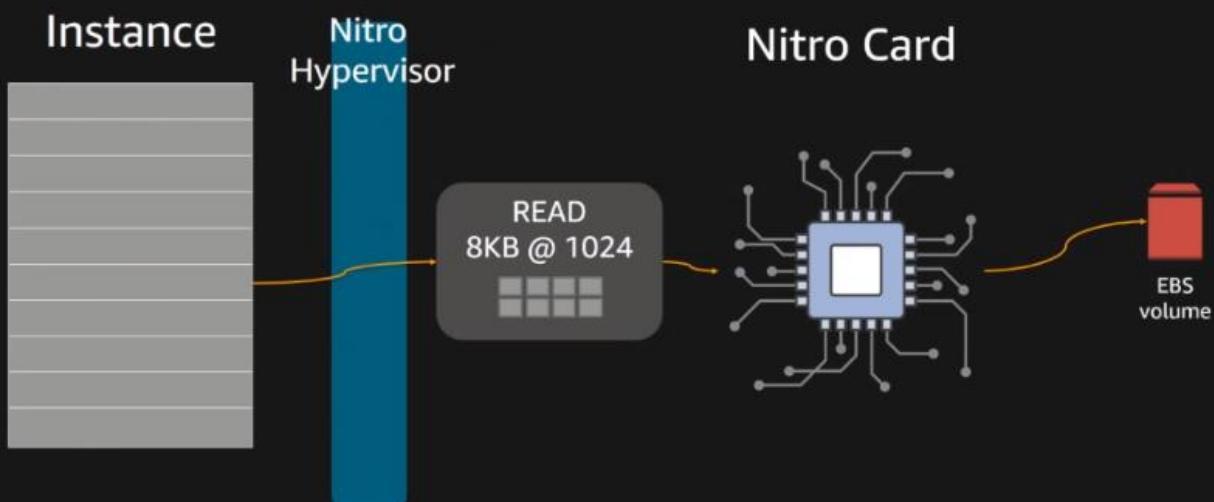
```
[ec2-user@ip-10-0-12-183 ~]$ lsblk
NAME      MAJ:MIN RM  SIZE RO TYPE MOUNTPOINT
nvme0n1    259:1    0   1G  0 disk
nvme0n1    259:0    0   8G  0 disk
└─nvme0n1p1 259:2    0   8G  0 part /
└─nvme0n1p128 259:3   0   1M  0 part

With ec2-utils:
[ec2-user@ip-10-0-12-183 ~]$ sudo /sbin/ebsnvme-id /dev/nvme0n1
EBS volume ID: vol-01324f611e2463981
Block device : /dev/xvdf

[ec2-user@ip-10-0-12-183 ~]$ ls -la /dev/xvdf
lrwxrwxrwx 1 root root 7 Oct 12 02:55 /dev/xvdf -> nvme0n1

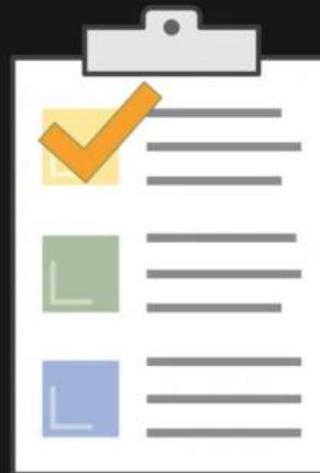
[ec2-user@ip-10-0-12-183 ~]$ ls -la /dev/disk/by-id/nvme-Amazon_Elastic_Block_Store_vo101324f611e2463981-ns-1
lrwxrwxrwx 1 root root 13 Oct 12 02:55 /dev/disk/by-id/nvme-Amazon_Elastic_Block_Store_vo101324f611e2463981-ns-1 ->
../../../../nvme0n1
```

A day in the life of an I/O: Nitro Hypervisor



EBS best practices

Security



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We offer EBS encrypted volumes and you can also roll your own encryptions too,

What is EBS encryption?



Encryption



- Boot and data volumes can be encrypted
- Attach both encrypted and unencrypted
- Most instance families
- No volume performance impact
- Supported by all EBS volume types
- Snapshots also encrypted
- No extra cost

Create Volume

Volume Type	Throughput Optimized HDD (ST1)
Size (GiB)	500 (Min: 500 GiB, Max: 16384 GiB)
IOPS	Not Applicable
Throughput (MB/s)	20/123 (Baseline: 40 MB/s per TiB)
Availability Zone	us-west-2a
Snapshot ID	Search (case-insensitive)
Encryption	<input checked="" type="checkbox"/> Encrypt this volume

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Best practice: Encryption



EBS encryption: data volumes

Create Volume

Volume Type: Throughput Optimized HDD (ST1)

Size (GiB): 500 (Min: 500 GiB, Max: 16384 GiB)

IOPS: Not Applicable

Throughput: 20/123 (Baseline of 40 MB/sec per TiB up to 500 MB/sec)

Availability Zone: us-west-2a

Snapshot ID: Search (case-insensitive)

Encryption: Encrypt this volume (circled)

Master Key: (default) aws/ebs (circled)

Key Details

Description: Default master key that protects my EBS volumes when no other key is defined

Account: This account (redacted)

KMS Key ID: redacted

KMS Key ARN: arn:aws:kms:us-west-2: redacted/key/redacted

Cancel Create

All accounts can create EBS volumes using the default EBS volume master key, this master key protects the key that actually encrypts your volume.

Best practice: Encryption

Create a new AWS KMS master key for EBS

Create Alias and Description

Provide an alias and a description for this key. These properties of the key can be changed later. [Learn more](#).

Alias (required): ebs-master

Description: Master EBS Encryption Key

- Define key rotation policy
- Enable AWS CloudTrail auditing
- Control who can use key
- Control who can administer key

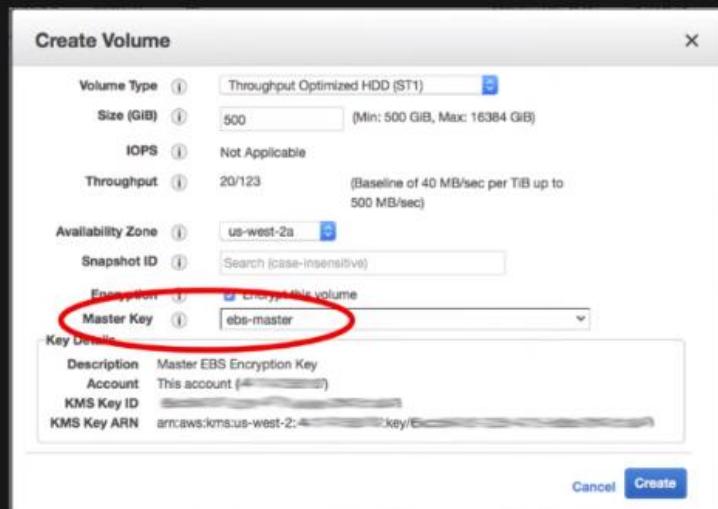
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The best practice is that you should create a new custom master key,

Best practice: Encryption

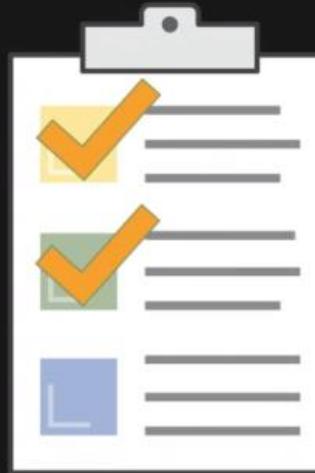


EBS encryption: data volumes



EBS best practices

Security
Reliability



Because EBS volumes persist beyond the life of your EC2 instance, we need to think about the reliability of EBS separate from EC2.

EBS is designed for...



99.999% service availability



0.1% to 0.2% annual failure rate (AFR)

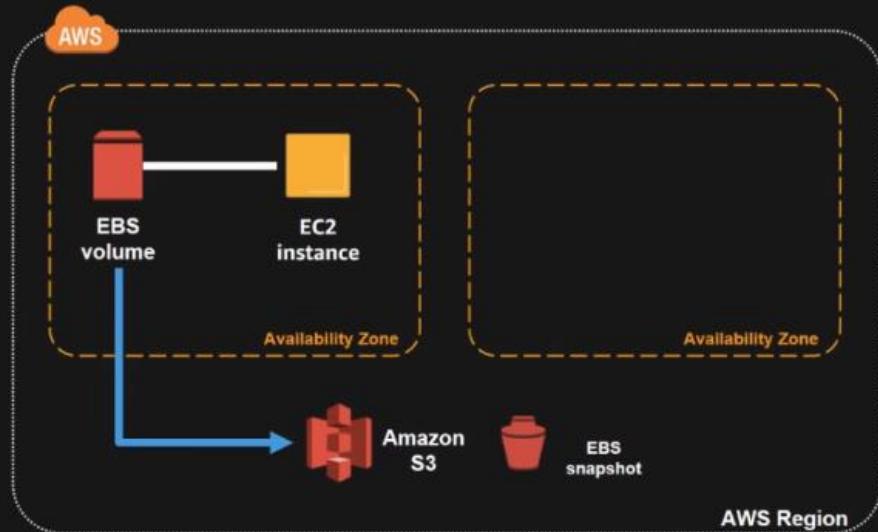


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Availability is the ability to access your data, durability is the ability to get data off your volume. You can further reduce the loss of your volume or data by taking regular snapshots.

What is an EBS snapshot?



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An EBS snapshot is a point-in-time, crash consistent copy of your data stored in S3.

How does an EBS snapshot work?



- Point-in-time backup of modified volume blocks
- Stored in S3, accessed via EBS APIs
- Subsequent snapshots are incremental
- Deleting snapshot will only remove data exclusive to that snapshot
- Crash consistent

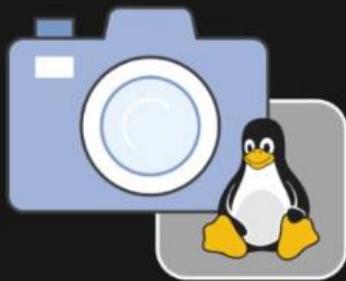
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The first time you take a snapshot, every modified block is copied to S3. Subsequent snapshots are incremental and only the changed blocks are copied.

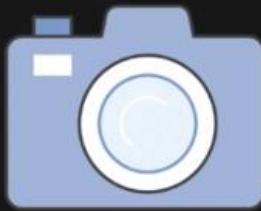
Best practice: Taking snapshots from Linux



Quiesce I/O

1. Database: `FLUSH and LOCK tables`
2. Filesystem: `sync and fsfreeze`
3. EBS: snapshot all volumes
4. When `CreateSnapshot API` returns success, it is safe to resume

Best practice: Taking snapshots from Windows



1. sync equivalent available
2. Use Volume Shadow Copy Service (VSS) - aware utilities for backups
3. EBS: backups on dedicated volume for snapshots

New: VSS support via EC2 SSM

- Use Policy Generator to create IAM policy for AWS Service "Amazon Simple Service Manager"
- Actions:
DescribeInstances, CreateTags, and CreateSnapshot
- Create Amazon EC2 type IAM role and attach to Windows instances

The screenshot shows the 'Edit Permissions' step of the IAM Policy Generator. It includes fields for Effect (Allow), AWS Service (AWS Application Discovery), Actions (Select Actions), Amazon Resource Name (ARN), and Add Conditions (optional). Below these are tables for Effect, Action, and Resource, with specific permissions listed. At the bottom are 'Cancel', 'Previous', and 'Next Step' buttons.

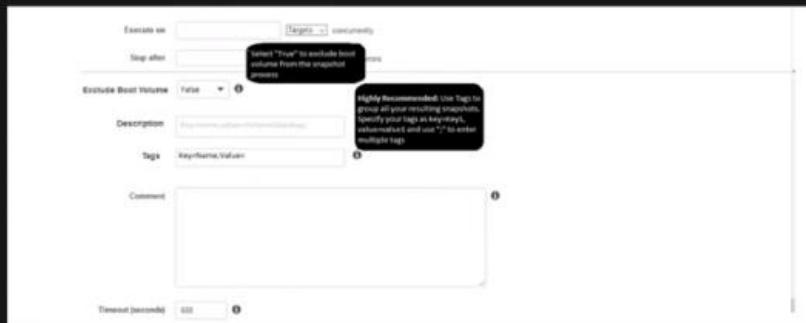
New: VSS support via EC2 SSM

- Call the Run Command
AWSEC2-CreateVssSnapshot

The screenshot shows the 'Run a command' section of the AWS Lambda Run Command interface. It displays a list of commands owned by the user or Amazon, including 'AWSEC2-CreateVssSnapshot'. Below the list are sections for 'Description', 'Select Targets By', and 'Select instances'.

New: VSS support via EC2 SSM

- Select the instance
- Add description, tags
- Can exclude boot volume
- Run Command makes the VSS agent flush I/O, freeze
- SSM VSS included in Microsoft Windows Server AMI version 2017.11.21 & up



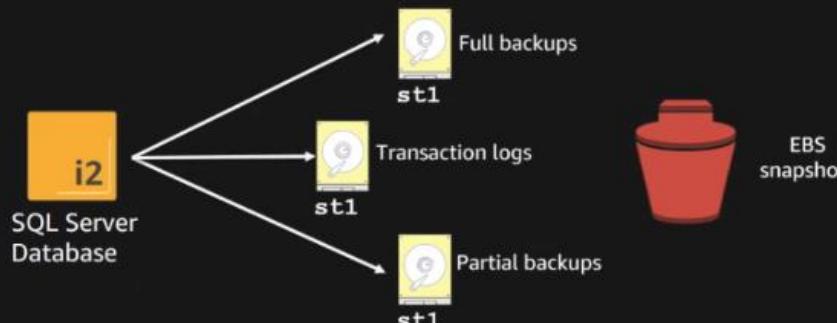
Hybrid volume use cases

Case study:

<https://aws.amazon.com/solutions/case-studies/infor-ebs/>

"We've seen much stronger performance for our database backup workloads with the Amazon EBS ST1 volumes, and we're also saving 75 percent on our monthly backup costs."

- Randy Young, director of cloud operations, Infor



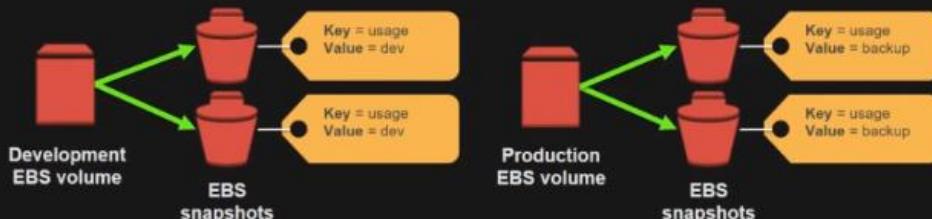
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Tracking snapshots and costs (tagging)

- Custom tags provide the ability to assign key/value pairs to AWS resources
- EBS snapshots support custom tags for identification and management
- EBS snapshot tags can be activated as “cost allocation” tags allowing for greater visibility into snapshot storage costs



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Tracking snapshots and costs (Cost Explorer)

First, activate customer tag for cost allocation

User-Defined Cost Allocation Tags

✓ Finished reading tags.

Activating tags for cost allocation tells AWS that the associated cost data for these tags should be made available throughout the billing period. Activated, cost allocation tags can be used as a dimension of grouping and filtering in Cost Explorer, as well as for refining AWS Budgets or CloudWatch Metrics.

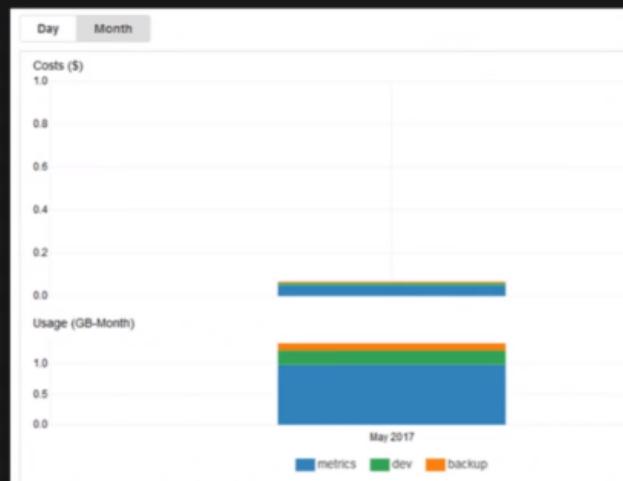
Clicking the Refresh button will prioritize your account for updates, so that tags from your linked accounts are visible to you sooner. Please note that this operation can only be triggered once every 24 hours.

Activate Deactivate Undo

Filter: All tags Tags per page: 100

Tag key usage

View usage and costs broken down by “usage” tag value
(example : metrics, dev, backup)



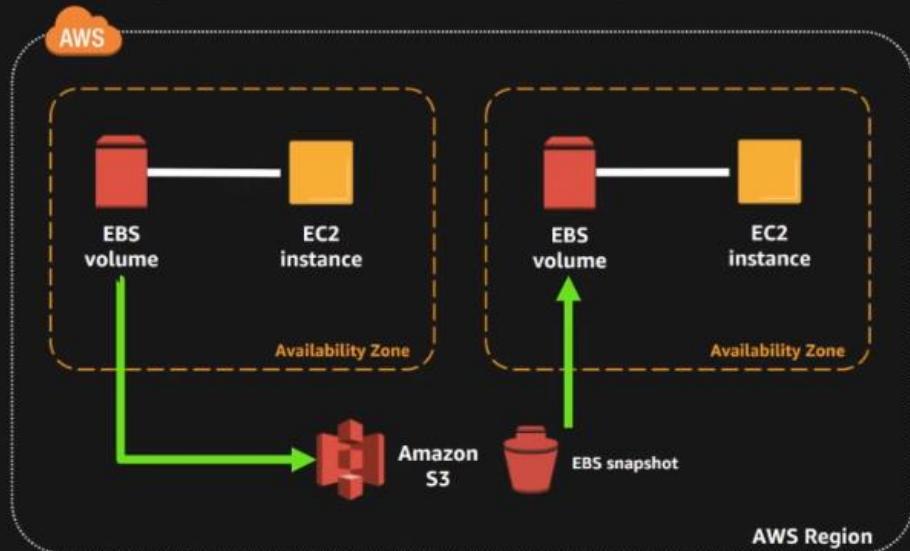
Generate reports with

AWS Cost and Usage Reports

Create report Delete

	Report name	S3 bucket	Time unit	Last updated
<input type="checkbox"/>	DailySnapshotUsage	jbarri-billing	Daily	2017-05-15
<input type="checkbox"/>	MyReport	jbarri-bcm	Hourly	2017-05-15
<input type="checkbox"/>	MyReportDaily	jbarri-bcm	Daily	2017-05-15

What can you do with a snapshot?

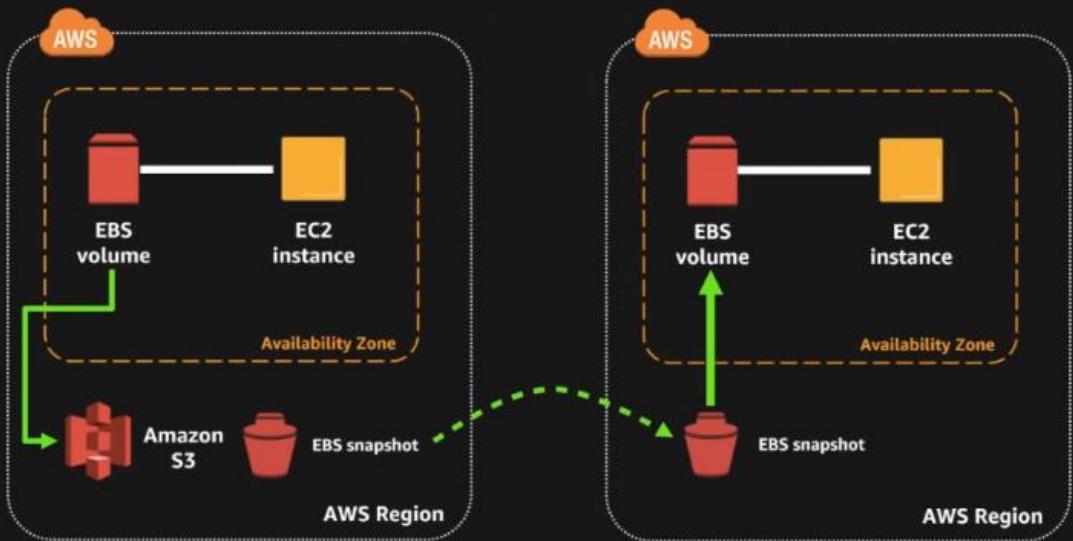


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What can you do with a snapshot?



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You can copy your snapshot to another region and use it to bootstrap new EC2 instances there for disaster recovery.

Best practice: Automate snapshots

Key ingredients:



AWS Lambda



Amazon EC2
Run Command



Tagging

<https://aws.amazon.com/answers/infrastructure-management/ops-automator/>

The link above will help you build a snapshot lifecycle management system. You can set policies on your snapshots to take snapshot weekly, daily, etc as well as retention policies where the snapshots get deleted after a month or some time frame.

EBS enables EC2 auto recovery

Amazon CloudWatch
per-instance metric alarm:
`StatusCheckFailed_System`

When alarm triggers?
RECOVER instance

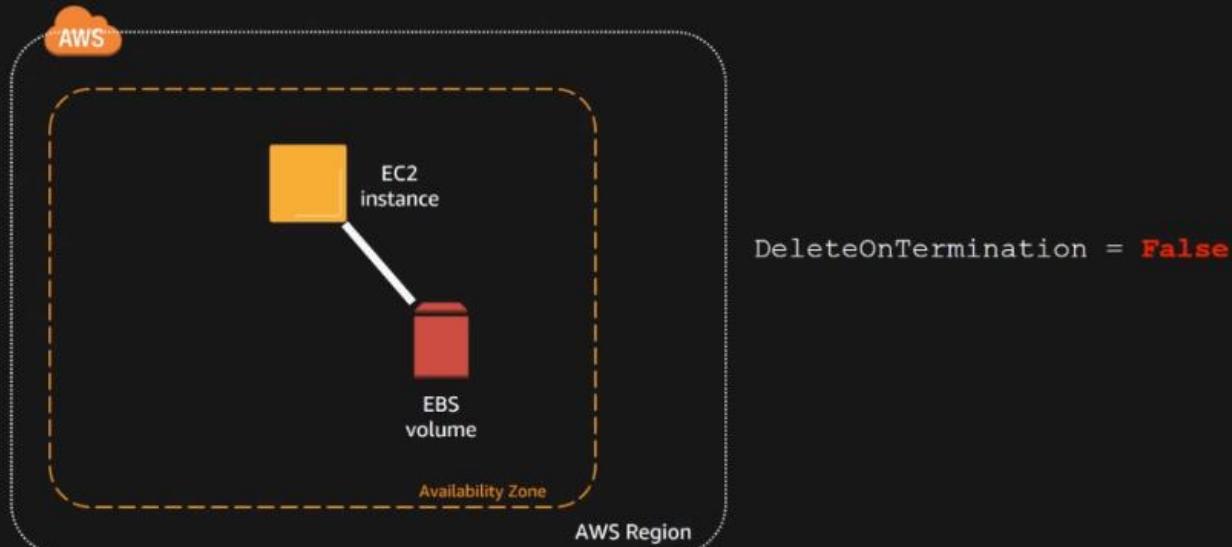


Instance retains:

- ✓ Instance ID
- ✓ Instance metadata
- ✓ Private IP addresses
- ✓ Elastic IP addresses
- ✓ EBS volume attachments

* Supported on C3, C4, C5, M3, M4, R3, R4, T2, and X1 instance types with EBS-only storage

What about EC2 instance termination?

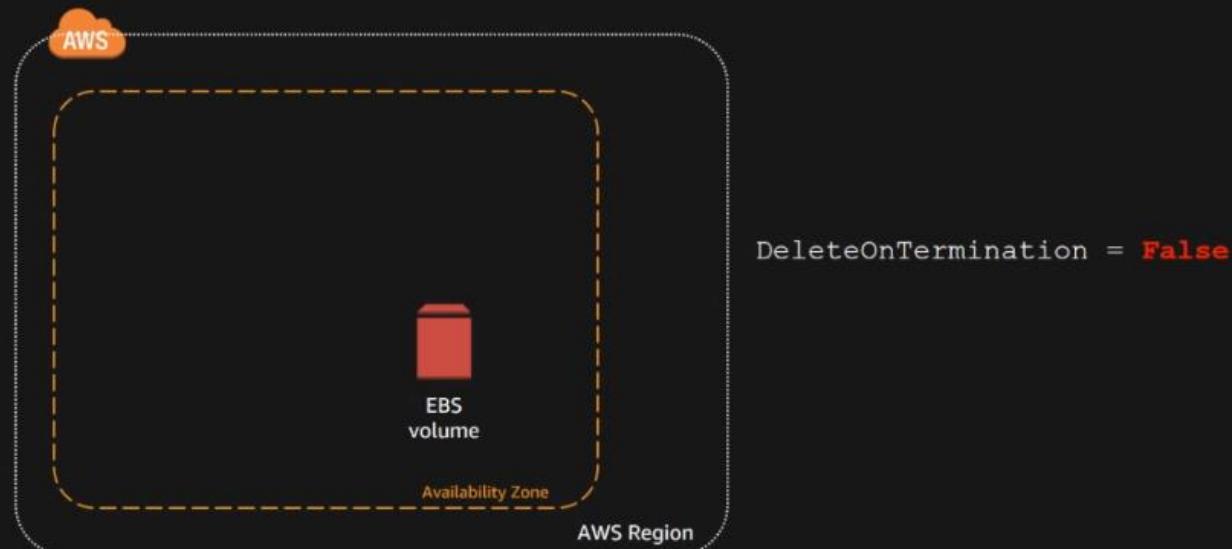


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By default, root volumes are tied to the life of the instance they are on while EBS data volumes are not.

What about EC2 instance termination?

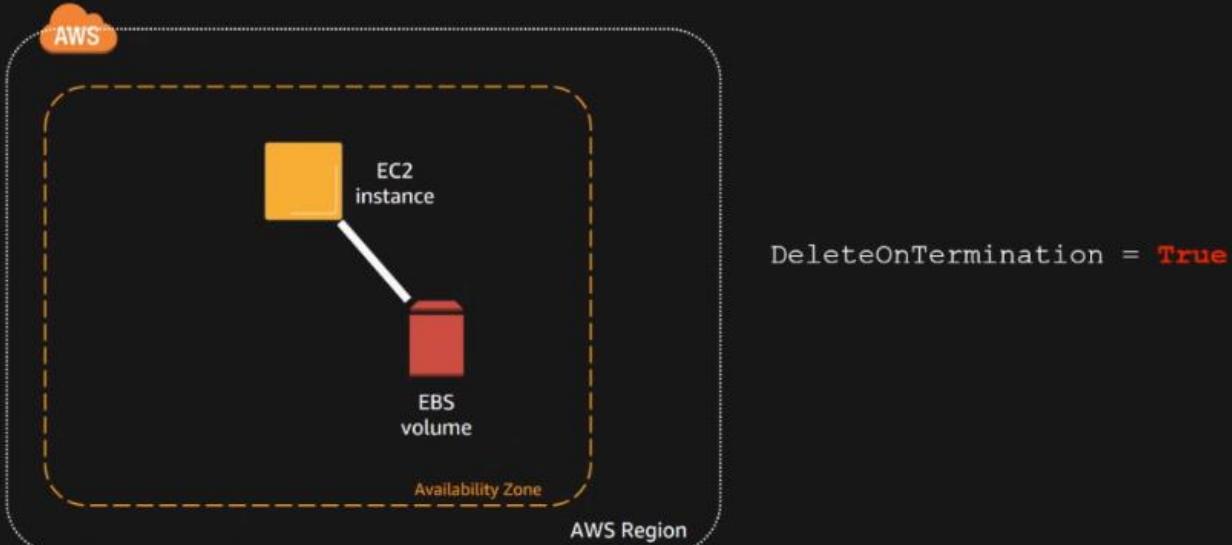


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When you terminate your instance, the EBS volume is still there. The best practice is that you tag your EBS volumes so that you know what data is on them.

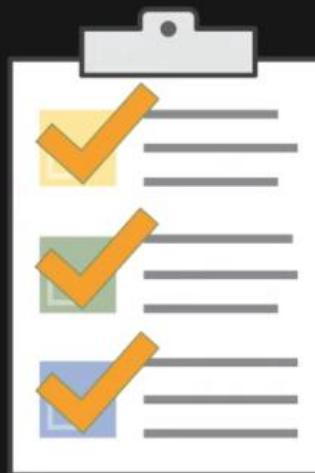
What about EC2 instance termination?



If you have a Dev and Test workload and you want to delete the EBS volumes automatically when the instance dies, you can simply set the DeleteOnTermination value to True on the EBS volume. This will reduce your cost.

EBS best practices

Security
Reliability
Performance



How do we count I/O?

When possible, we **logically** merge sequential I/Os

...To *minimize* I/O charges on io1,
and *maximize* burst on gp2, sc1, and st1

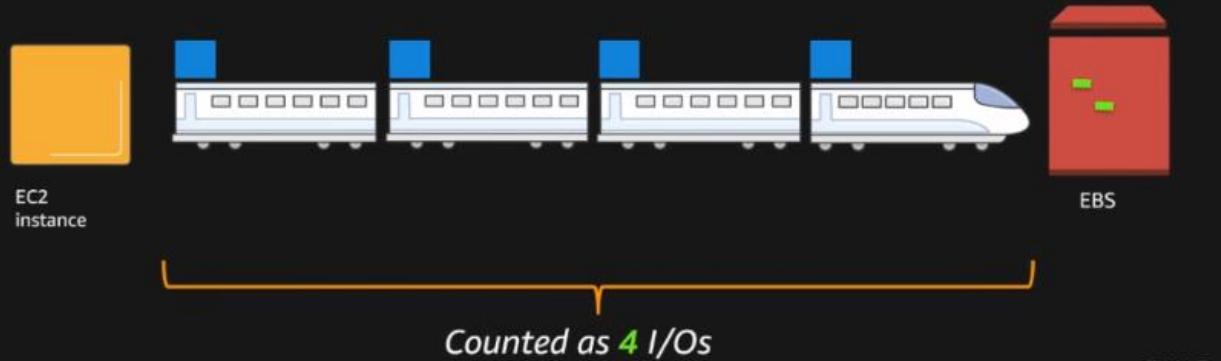
io1 and gp2: up to 256KiB

st1 and sc1: up to 1MiB

How do we count I/O?

Example 1: Random I/Os

- 4 random I/Os (i.e., non sequential I/Os)
- Each I/O **64 KiB**



How do we count I/O?

Example 2: Sequential I/O

- 4 sequential I/Os
- Each I/O **64 KiB**



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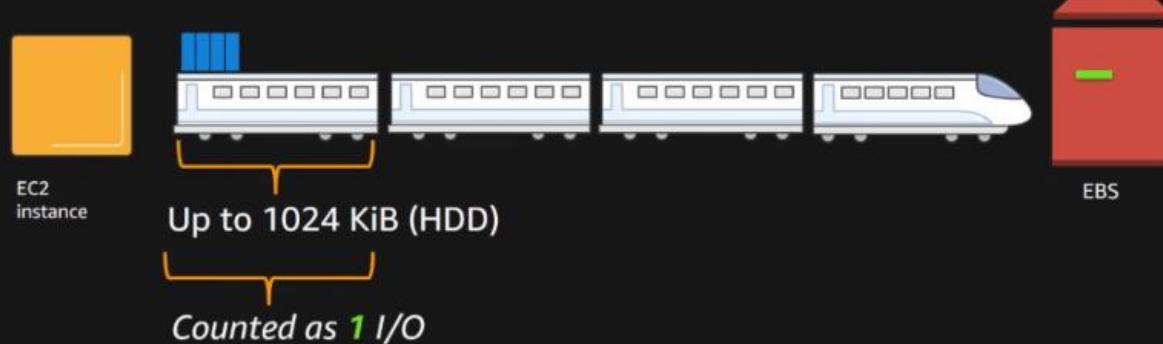
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How do we count I/O?

Example 2: Sequential I/O

- 4 sequential I/Os
- Each I/O **64 KiB**



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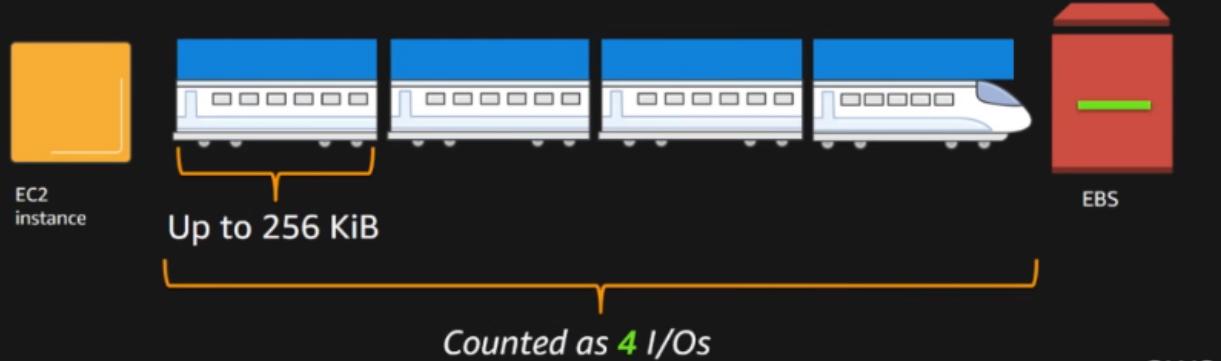
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How do we count I/Os for GP2 and IO1?

Example 3: Large I/O

- 1 I/O
- 1024 KiB



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How do we count I/Os for ST1 and SC1?

Example 4: Mixed I/O

- 2 * 512 KB sequential I/Os
- 2 * 64 KB random I/Os
- 2 * 128 KB sequential I/Os

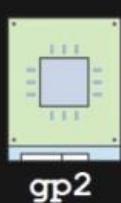


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Burst bucket: gp2

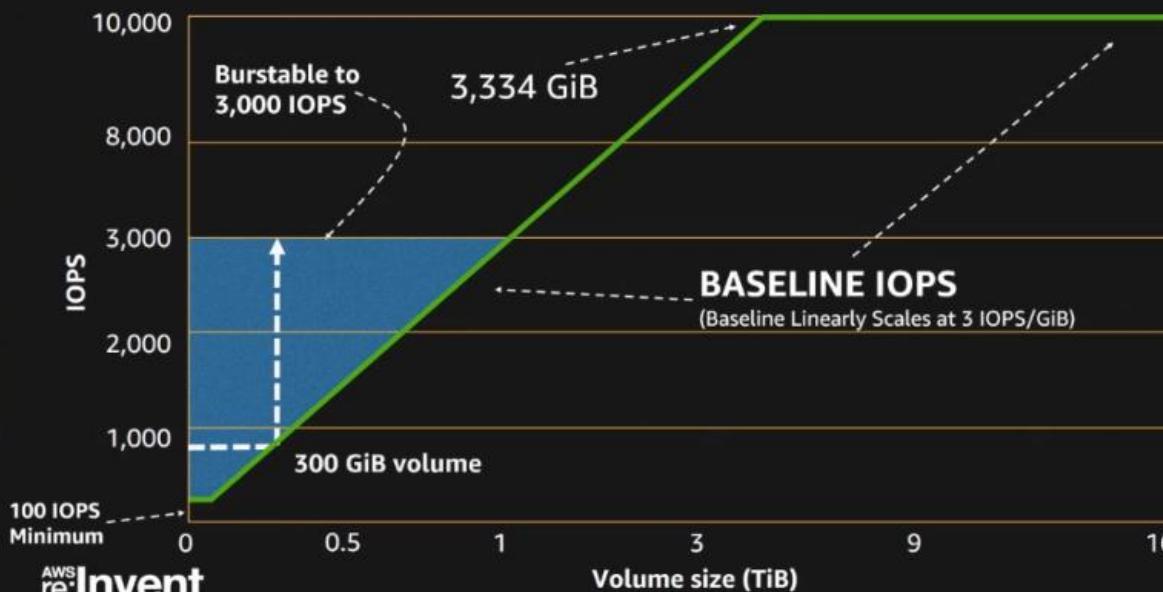


Baseline performance:
Always accumulating
3 IOPS per GiB per second

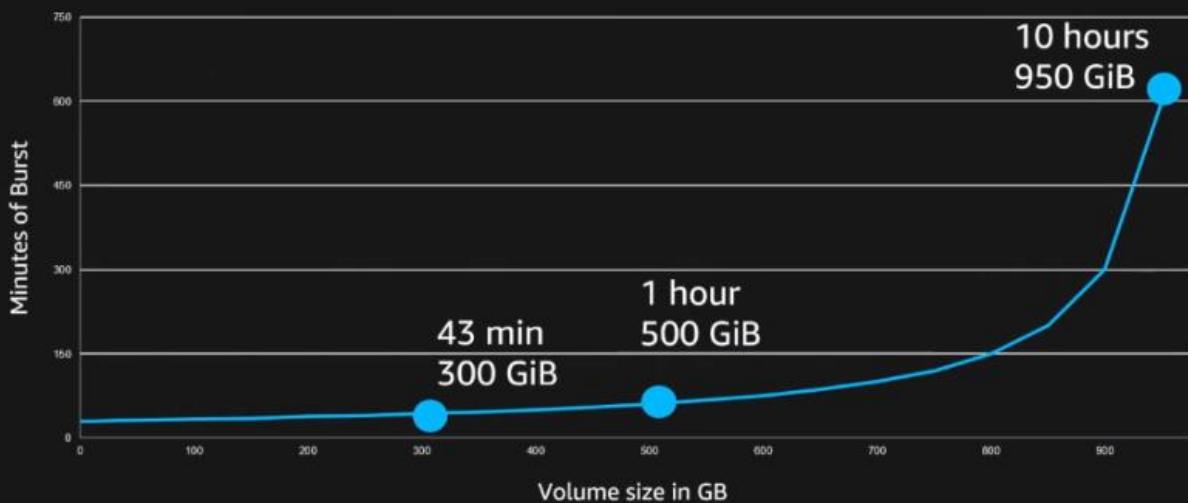
Max I/O credit per bucket is 5.4M

Burst performance:
You can spend up to
3,000 credits per second

Burst and baseline: gp2



How long can I burst on gp2?



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Burst bucket: Throughput



st1/sc1



Baseline performance:
Always accumulating
st1: 40MiB/s per TiB
sc1: 12MiB/s per TiB

Max I/O bucket credit is 1 TiB of credit per TiB in volume

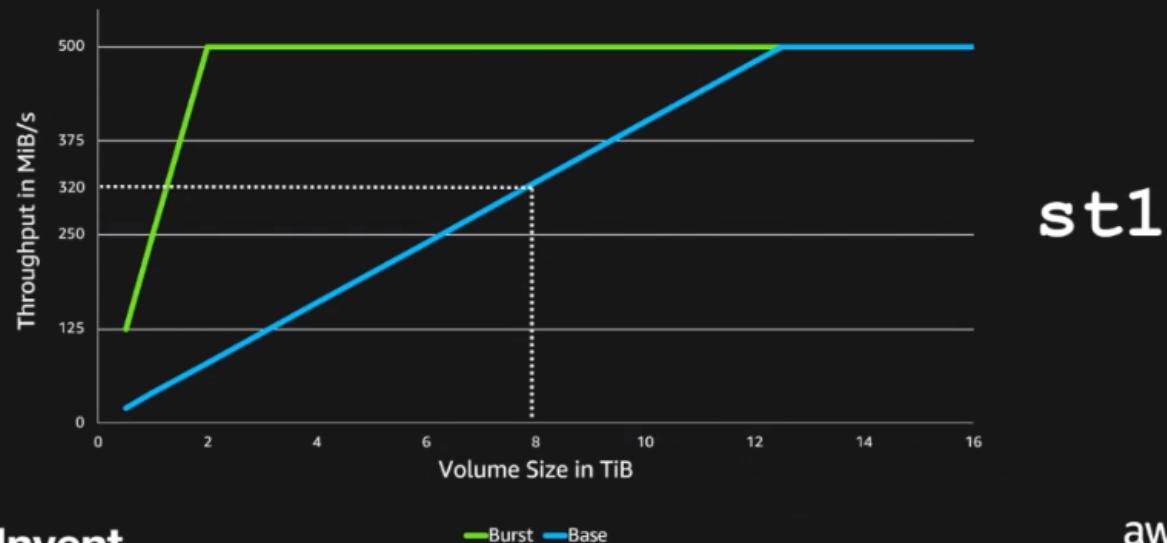
Burst performance:
Spend up to
st1: 500 MiB/s
sc1: 250 MiB/s

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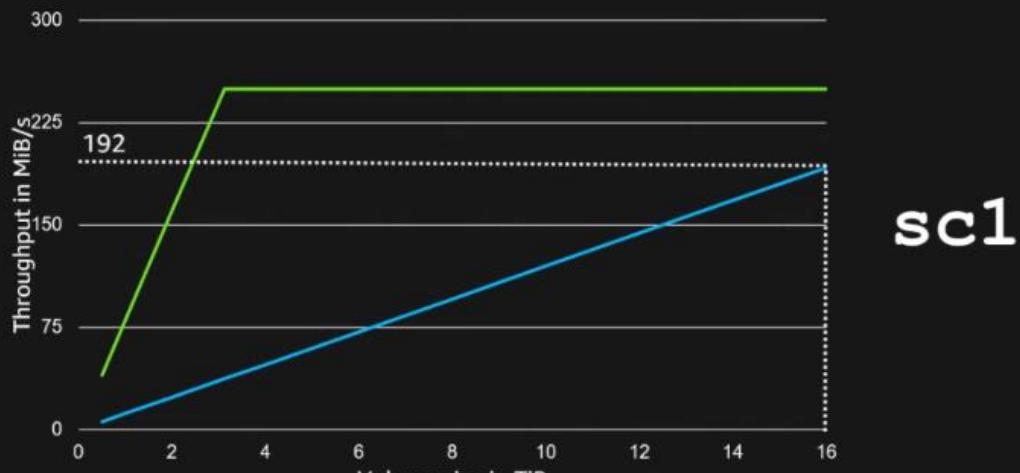
Burst & baseline: st1



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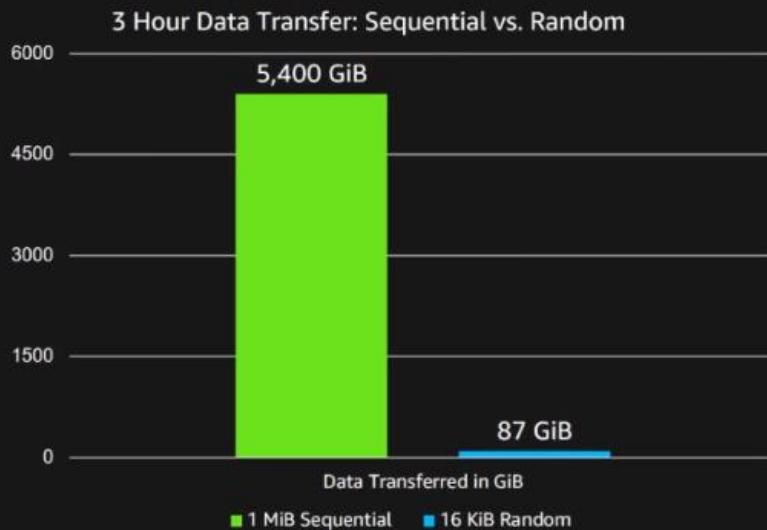
Burst & baseline: sc1



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Burst balance for ST1 and SC1



4 TiB ST1 Volume

1 MiB Sequential:
5.4 TiB transferred

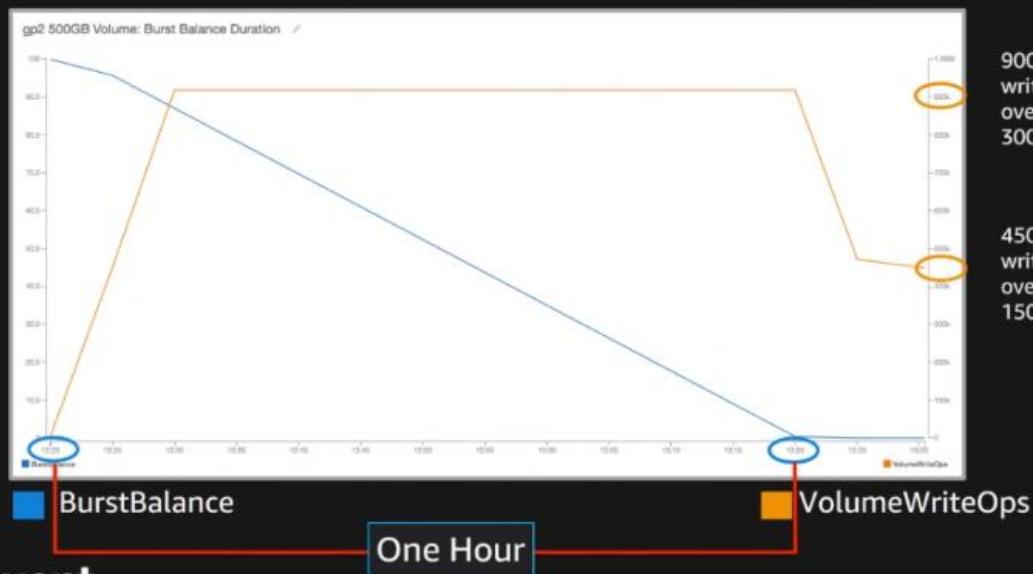
16 KiB Random:
87 GiB transferred

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How do I monitor my burst balance?



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Verify workload I/O patterns

iostat for Linux

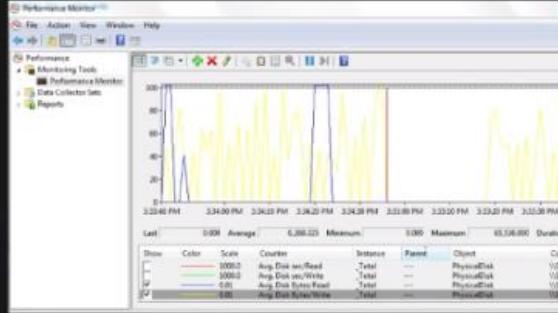
```
$ iostat -xm
Device: rrqm/s wrqm/s r/s w/s rMB/s wMB/s avgrq-sz avgqu-sz await svctm %util
xvdf    0.00     0.20  0.00 523.40  0.00 523.00 2046.44    3.99    7.62   1.61 100.00
```

$$2046 \text{ sectors} \times 512 \text{ bytes/sector} = \sim 1024 \text{ KiB}$$

perfmon for Windows



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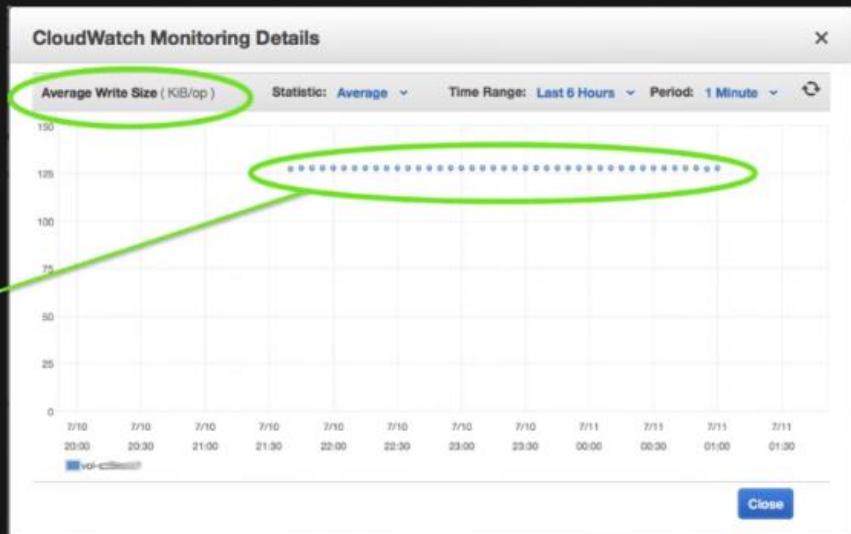


Verify ST1 & SC1 workloads

128 KiB



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Verify ST1 & SC1 workloads



Amazon
CloudWatch
console

Under 64
KiB?

Small or
random IOPS
likely



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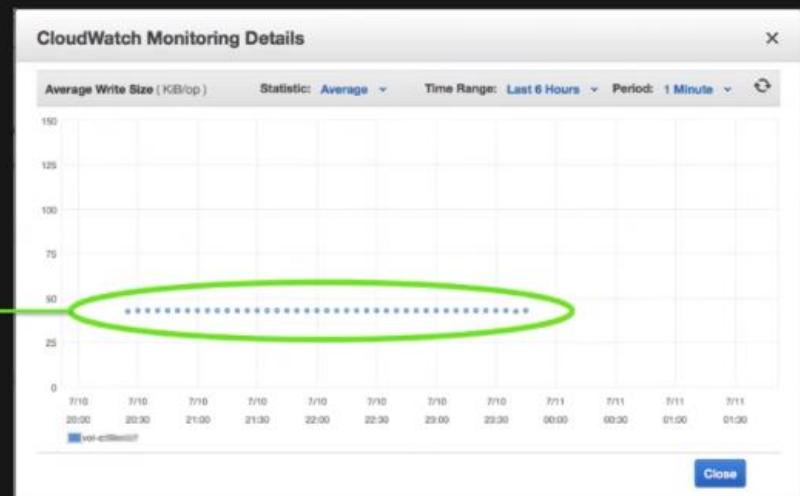


Verify ST1 & SC1 workloads



Amazon
CloudWatch
console

Stuck
around 44
KiB?



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Linux performance tuning: st1 & sc1

Increase read-ahead buffer:



- Recommended for high-throughput read workloads
- Per volume configuration
- Default is 128 KiB (256 sectors) for Amazon Linux
- Smaller or random I/O will degrade performance

For example:

```
$ sudo blockdev -setra 2048 /dev/xvdf
```

<https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/EBSPerformance.html>



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Linux performance tuning: Xen

Increase maximum I/O size:



- Recommended for all high-throughput workloads
- Per instance configuration for all volumes
- Default is 128 KiB (32 pages) for Amazon Linux
- Increased memory consumption per volume

3.10 – 4.5:

```
kernel /boot/vmlinuz-4.4.5-15.26.amzn1.x86_64 root=LABEL=/ console=ttyS0 xen_blkfront.max=256
```

4.6+:

```
kernel /boot/vmlinuz-4.9.20-11.31.amzn1.x86_64 root=LABEL=/ console=ttyS0
xen_blkfront.max_indirect_segments=256
```

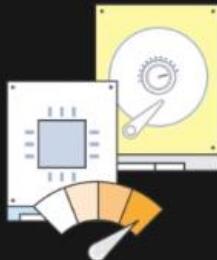
<https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/EBSPerformance.html>



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What is an EBS-optimized instance?

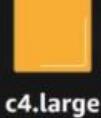


- Dedicated network bandwidth for EBS I/O
- Enabled by default on most current generation instances
- Can be enabled at instance launch or on a running instance
- Not an option on some 10 Gbps instance types
 - (c3.8xlarge, r3.8xlarge, i2.8xlarge)

More details:

<https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/EBSOptimized.html>

Performance: EBS-optimized



Dedicated to EBS

500 Mbps ~ 62.5 MiB/s
4,000 16K IOPS



2 TiB GP2 volume:
6,000 IOPS
160 MiB/s max throughput



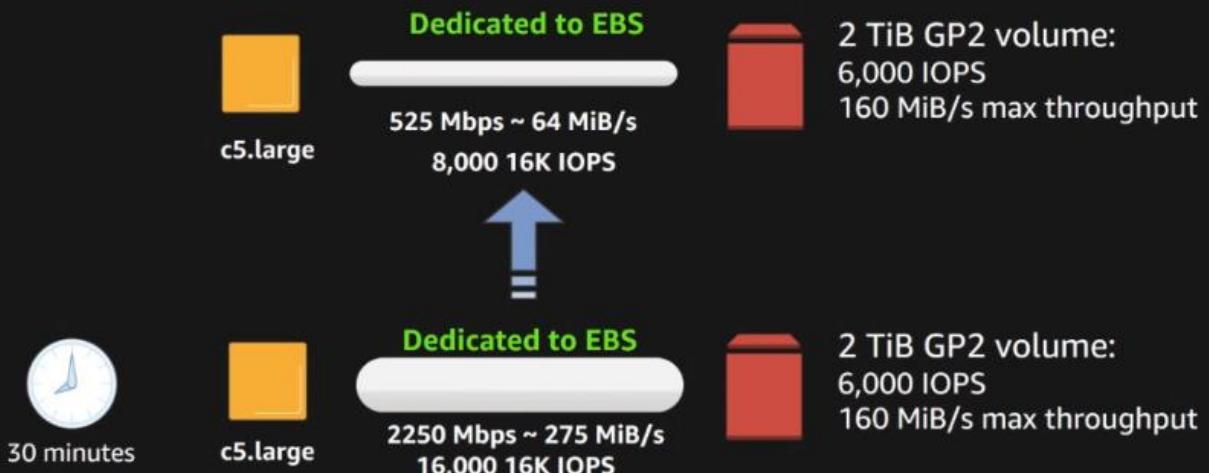
Dedicated to EBS

1 Gbps ~ 125 MiB/s
8,000 16K IOPS



2 TiB GP2 volume:
6,000 IOPS
160 MiB/s max throughput

Performance: EBS-optimized burst

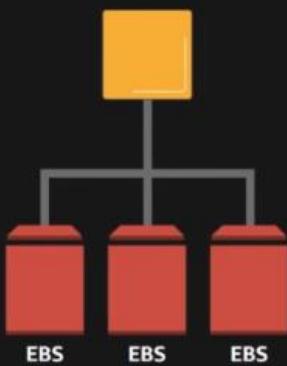


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Best practice: RAID



When to RAID?

- Storage requirement > 16 TiB
- Throughput requirement > 500 MiB/s
- IOPS requirement > 20,000 @ 16K

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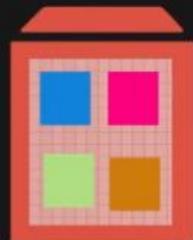
If you need more storage than 16TB or more throughput than 500MB/s or more IOPS than 20,000. You can join volumes together as above.

EBS volume initialization



New EBS volume?

- Attach and it's ready to go



New EBS volume from snapshot?

- Initialize for best performance
- Random read across volume



<https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/ebs-initialize.html>

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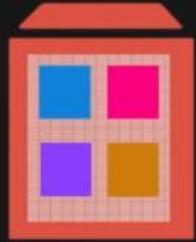
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Best practice: EBS volume initialization

Fio-based example:

```
$ sudo yum install -y fio
$ sudo fio --filename=/dev/xvdf --rw=randread --bs=128k --iodepth=32
--ioengine=libaio --direct=1 --name=volume-initialize
```



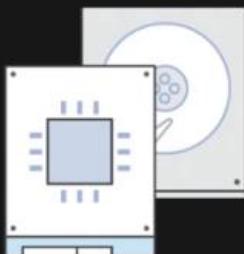
<https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/ebs-initialize.html>

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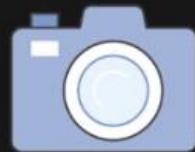
Summary



Select the right volume for your workload



Select the right instance for your workload



Take snapshots, tag snapshots



Use encryption if you need it



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New Storage Training



For Enterprise Storage Engineers

- Learn how to architect and manage highly available solutions on AWS storage services
- Advance toward AWS certifications
- Help your organization migrate to the cloud faster

Online at www.aws.training

- Access 100+ new digital training courses including advanced training on storage.
- Deep Dives on S3, EFS, and EBS
- Migrating and Tiering Storage to AWS (Hybrid Solutions)

At re:Invent

- Visit Hands-on Labs at the Venetian
- Attend a proctored "Introduction to EFS" Spotlight Lab on Thursday at 3pm at the Venetian
- Meet Storage experts at the Ask the Experts in Hands-on Labs room at the Venetian

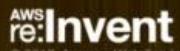


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