Research: How can we decouple the IoT data from the virtual machine and store them on a separate EBS (data) volume?

Context

The creation of various cloud services is done using `CloudFormation` templates. CloudFormation is Amazon's Infrastructure as Code (IaaC) tool, allowing infrastructure to be set up through code. This approach makes it possible to easily create and modify infrastructure without having to make changes through an administrator panel.

However, the current process is not ideal and causes some issues in certain cases.

When changes are made to the `CloudFormation` templates, Amazon sometimes decides not to apply these changes to the existing infrastructure. Instead, Amazon chooses to completely remove and rebuild the infrastructure with the applied changes. This results in the loss of all data on the existing infrastructure, including data from the IoT platform. It is difficult to predict when Amazon will take this drastic measure. Sometimes this happens only with large changes, but even smaller modifications can lead to this outcome. Due to this uncertainty, the update process is considered risky. To prevent errors and potential data loss, OpenRemote has decided to perform the process manually.

Before each update, a `snapshot` (backup) of the `virtual` machine is created. This snapshot contains both the IoT platform data and a copy of the operating system. If an issue occurs during or after the update, the `snapshot` can be quickly restored, resulting in minimal downtime for the customer. In this situation, no data is lost.

Manually updating the `virtual` machines is a time-consuming process. As the number of customers using the 'managed' service increases, more time is spent on these tasks. Therefore, OpenRemote is looking for ways to further automate this process. This research focuses on storing the IoT data on a separate `EBS` data volume so that backups can be more targeted, reducing the risk of data loss during updates by decoupling the data from the `virtual` machine.

DOT Framework

For this research, the following methods from the DOT Framework are used:

- `Literature Study` (To investigate how Amazon EBS and the Lifecycle Policy Manager function, as well as to understand how the filesystem works within Linux and can be used for setting up external block devices)
- `Gap Analysis` (To get an overview of the current situation and the desired situation)
- `Decomposition` (To visualize and understand how the current situation is functioning)
- `Prototyping` (To explore how potential solutions perform within the context of OpenRemote)
- `System Tests` (To test the potential solutions using various test cases, ensuring that the solution functions as expected)

Contents

1. Situation

In this section, I will discuss the current situation and the desired outcome. Additionally, it will provide an overview of the bridges that need to be built to reach the new situation.

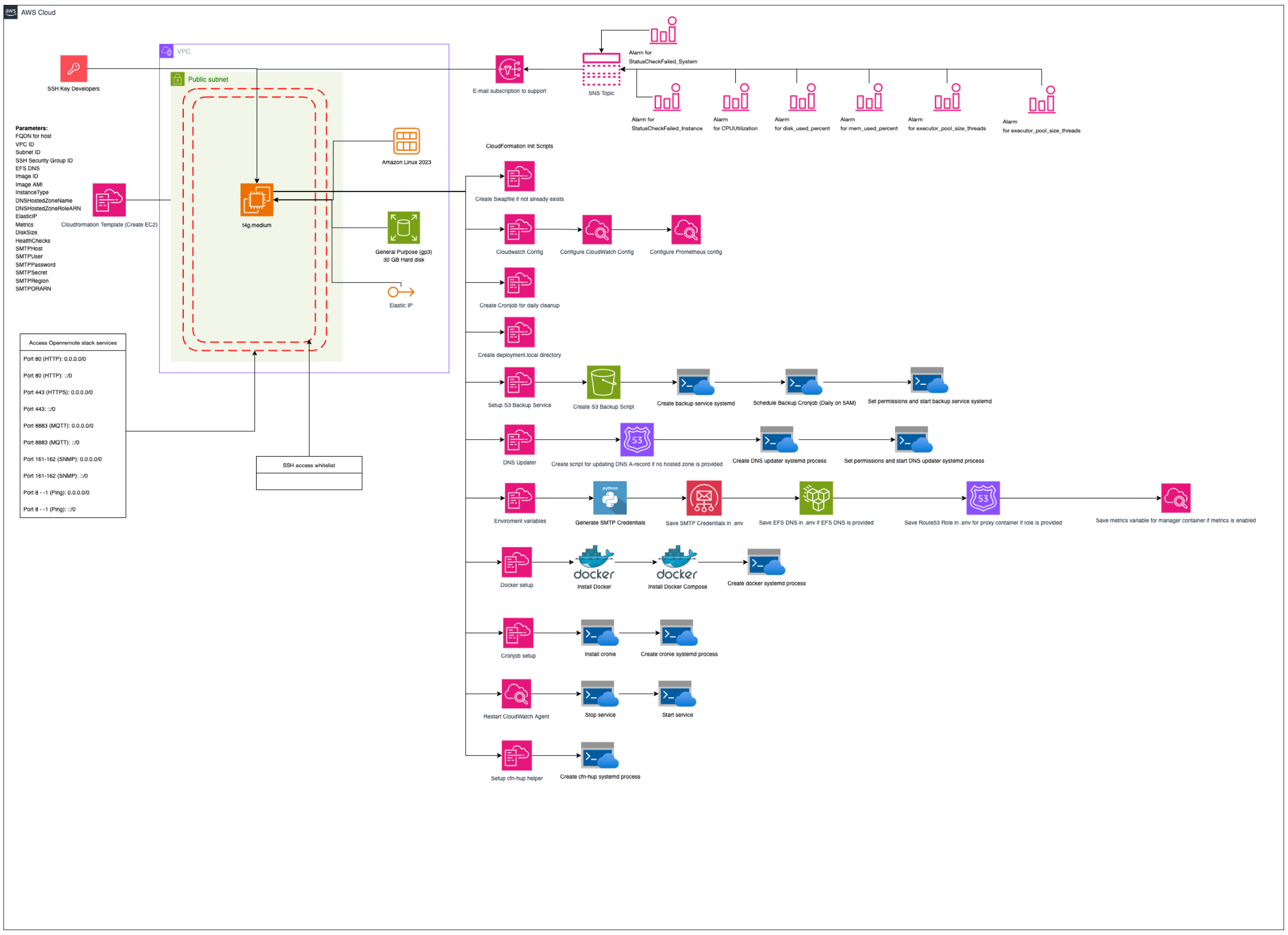
1.1. Current Situation

The picture below gives an overview of the current situation. The `EC2` machine is created with an `CloudFormation` template. The machine is using the default `Amazon Linux 2023 AMI` (Amazon Machine Image) and is provisoned with 30 GB of `gp3` (General Purpose) block storage. Optionally there will be a `Elastic IP` assigned to the `EC2` instance. The `EBS` volume is used for both the operating system and data storage and no additional volumes or partitions are being created.

During the execution of the `CloudFormation` template `cfn-init` runs several scripts after the machine is booted. These scripts setup the following services on the `EC2` instance.

- The system creates a `swapfile` if not already exists.
- The system configures the `CloudWatch` agent.
- The system creates an `cronjob` for daily cleanup (vacuum).
- The system creates an `deployment.local` directory.
- The system creates an `S3` bucket for storing backups if not already exists and synchronises the contents to the bucket. There will be an `systemd` process created for executing the backup task as well as an `cronjob` for executing it every day on 5AM.
- The system sets the permissions and starts the backup services.
- The system creates an `DNS A-record` update script if no `Hosted Zone Name` is provided and creates an `systemd` process for it.
- The system sets the permissions and starts the DNS update service.
- The system executes an `Python` script that genereates `SMTP` credentials for Amazon `SES`.
- The system configures the `.env` variables for Amazon `SES`, `EFS`, `Route53` and `CloudWatch` depending on the `.env` variable
- The systems installs `Docker` and `Docker Compose` and creates and `systemd` process for it.
- The system installs `Cronie` and creates and `systemd` process for it.
- The system restarts the `CloudWatch` agent.
- The system configures the `cfn-hup` helper that detects changes in the resource metadata and creates and `systemd` process for it.

The system also configures `CloudWatch` and creates some alarms for several metrics. When an alarm is triggered, an e-mail will be sent to OpenRemote. This is configured via the `SNS` subscription/topic.


AWS Cloud
SSH Key Developers
VPC
Public subnet
Parameters:
FQDN for host
VPC ID
Subnet ID
SSH Security Group ID
EFS DNS
Image ID
Image AMI
InstanceType
DNSHostedZoneName
DNSHostedZoneRoleARN
ElasticIP
Metrics
DiskSize
HealthChecks
SMTPHost
SMTPUser
SMTPPassword
SMTPSecret
SMTPRegion
SMTPORARN
Cloudformation Template (Create EC2)
t4g.medium
Amazon Linux 2023
General Purpose (gp3) 30 GB Hard disk
Elastic IP
Access Openremote stack services
Port 80 (HTTP): 0.0.0.0/0
Port 80 (HTTP): ::/0
Port 443 (HTTPS): 0.0.0.0/0
Port 443: ::/0
Port 8883 (MQTT): 0.0.0.0/0
Port 8883 (MQTT): ::/0
Port 161-162 (SNMP): 0.0.0.0/0
Port 161-162 (SNMP): ::/0
Port 8 - -1 (Ping): 0.0.0.0/0
Port 8 - -1 (Ping): ::/0
SSH access whitelist
E-mail subscription to support
SNS Topic
Alarm for StatusCheckFailed_System
Alarm for StatusCheckFailed_Instance
Alarm for CPUUtilization
Alarm for disk_used_percent
Alarm for mem_used_percent
Alarm for executor_pool_size_threads
Alarm for executor_pool_size_threads
CloudFormation Init Scripts
Create Swapfile if not already exists
Cloudwatch Config
Configure CloudWatch Config
Configure Prometheus config
Create Cronjob for daily cleanup
Create deployment.local directory
Setup S3 Backup Service
Create S3 Backup Script
Create backup service systemd
Schedule Backup Cronjob (Daily on 5AM)
Set permissions and start backup service systemd
DNS Updater
Create script for updating DNS A-record if no hosted zone is provided
Create DNS updater systemd process
Set permissions and start DNS updater systemd process
Enviroment variables
Generate SMTP Credentials
Save SMTP Credentials in .env
Save EFS DNS in .env if EFS DNS is provided
Save Route53 Role in .env for proxy container if role is provided
Save metrics variable for manager container if metrics is enabled
Docker setup
Install Docker
Install Docker Compose
Create docker systemd process
Cronjob setup
Install cronie
Create cronie systemd process
Restart CloudWatch Agent
Stop service
Start service
Setup cfn-hup helper
Create cfn-hup systemd process

There are several things happening simultaneously in this scenario. The EC2 instance is using a single root block device, which means there is no separation between the system data and application data. The volume has been configured with the property `DeleteOnTermination=true`, meaning it will be deleted when the instance is terminated.

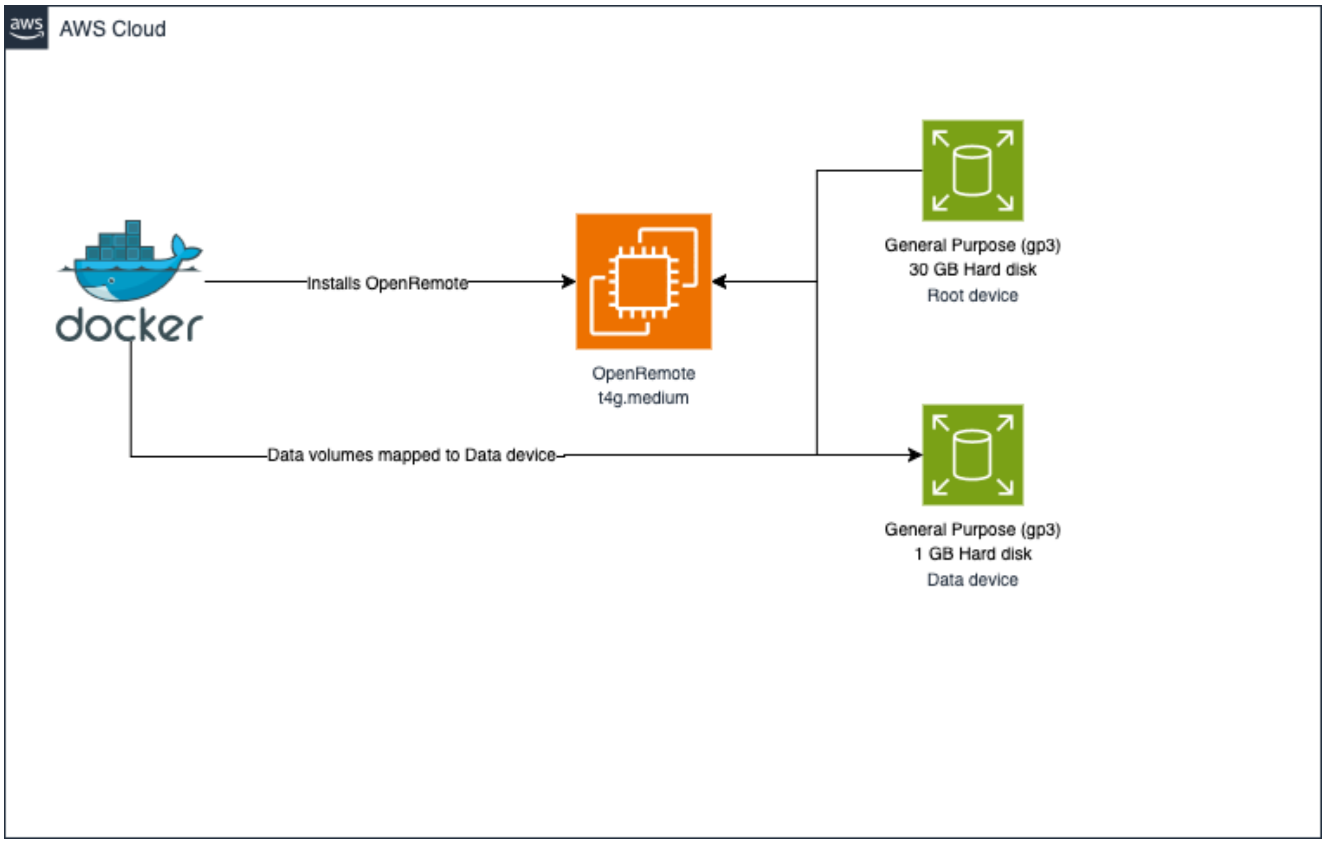
However, simply changing this setting is not enough to access the IoT data easily. This is because the volume is also serving as the boot drive for the operating system.

When changes are made to the `CloudFormation` template, there is a possibility that the EC2 instance will be recreated to apply the updates. This could result in the termination of both the instance and its associated volume, along with the data stored on it.

1.2. Desired Situation

To solve this issue, I suggest decoupling the IoT data from the root volume and storing it on a separate EBS data volume. This approach simplifies data backup since it is no longer tied to the boot device and can be attached to other EC2 (OpenRemote) instances. These instances can seamlessly access the same data and connections.

Additionally, by detaching the data from the root volume, there is no risk of data loss during `CloudFormation` updates. This opens up new possibilities, such as creating test instances with specific data or enabling `blue/green deployments`. With this setup, a new instance can be launched with the necessary data while the existing instances are being updated.


AWS Cloud
docker
Installs OpenRemote
OpenRemote
t4g.medium
General Purpose (gp3)
30 GB Hard disk
Root device
Data volumes mapped to Data device
General Purpose (gp3)
1 GB Hard disk
Data device

2. Amazon Elastic Block Storage (EBS)

In this section, I will discuss both the opportunities and challenges I have encountered during my research on Amazon Elastic Block Storage (`EBS`).

2.1. What is Amazon Elastic Block Storage (EBS)?

Amazon Block Storage provides scalable, high-performance block storage that integrates seamlessly with Amazon Elastic Compute Cloud (`EC2`). You can create volumes that attach to `EC2` instances, enabling you to store files and install applications just like on a traditional hard drive. Additionally, you can create snapshots, which are point-in-time backups of your volumes. These snapshots allow for quick data recovery and you can easily create new volumes from a snapshot.

Amazon `EBS` offers the following features:

- `Volume types`: Choose from a variety of volume types, including standard `HDD`, `SSD`, and `I/O-optimized` SSD drives. These volumes can be upgraded or downgraded without any downtime, providing excellent scalability.
- `Snapshots`: You can create snapshots of existing volumes and use them to create new volumes. These snapshots can be shared with other AWS accounts or moved to different availability zones.
- `Encryption`: Volumes can be encrypted using Amazon's AES-256 encryption standard. The encryption is handled on the server, ensuring that both volumes and snapshots are encrypted at rest and during data transit. You can use Amazon's default KMS encryption key or create your own for more access control.
- `Archiving`: Snapshots can be archived for a minimum of 90 days at a low cost, making it ideal for storing backups that are rarely accessed or for meeting compliance requirements.

2.2. Volume Types

There are several volume types to choose from. Since OpenRemote exclusively uses `SSD` drives, `HDD` drives will not be included in this list.

- `General Purpose gp2/3`: The SSD volume is ideal for a wide range of workloads, including virtual desktops and boot volumes. The minimum volume size is 1 GB, and it can be expanded up to 16 TB. However, this drive does not support multi-attach, meaning it can only be attached to one `EC2` instance at the same time.
- `iO Block Express io1/io2`: The SSD volume is optimized for higher `IOPS`, with a minimum size of 4 GB and the ability to scale up to 64 TB. In addition to its high performance, the drive supports multi-attach, allowing it to be attached to multiple `EC2` instances simultaneously.

This feature can be particularly useful in OpenRemote's use case for creating test instances or updating a specific instance without downtime.

Currently, OpenRemote is using `gp3` drives for their `EC2` instances, which handle the workload without any issues. As a result, there is no need to upgrade them, except in one specific use case. Since `io` drives support multi-attach, they can be attached to multiple instances simultaneously, opening up new possibilities like `blue/green deployments`. When OpenRemote decides to integrate this option, a migration will be required.

2.3. Pricing

Pricing varies based on the region where the resources are deployed. Since OpenRemote uses `eu-west-1` as their primary region, the prices listed below will apply on this.

- `General Purpose gp3`: $0,088/GB per month
- `General Purpose gp2`: $0,11/GB per month
- `iO Block Express io2`: $0,138/GB per month
- `iO Block Express io1`: $0,138/GB per month with an additional charge of $0.072 per provisioned `IOPS` per month

The prices above only reflect storage costs. Additional charges apply for the amount of `IOPS` and `throughput` provisioned. Since OpenRemote is not modifying these values and the default values are free of charge, they are not included in the list.

Based on the values that are provided in the `CloudFormation` template, OpenRemote is currently using `30 GB` of `gp3` storage. The calculation below gives an estimated of their montly storage costs for a single `EC2` instance using `30 GB` of `gp3` storage .

$0,088/GB * 30 GB = $2.64 per month.

When switching to the `io2` volume, the costs would be as follows: $0,138/GB * 30 GB = $4.14 per month.

When switching to the `io1` volume, the costs would be as follows: $0,138/GB * 30 GB = $4.14 per month.

As you can see, the prices for both `io1` and `io2` are the same, despite the additional `IOPS` charge. This is because there is a free baseline of 3000 `IOPS`, and OpenRemote is not changing these values.

The price difference between `io` drives and `gp` drives is minimal. When creating an additional volume for storing IoT data, the root device can easily be scaled down to reduce costs, as it doesn't require much space. In this case, the costs would be approximately the same. To further reduce costs, OpenRemote can consider auto-scaling the volumes based on the actual amount of storage needed. Since `EBS` pricing is based on the amount of GB provisioned, not the amount used, this approach can help lower the bill even further.

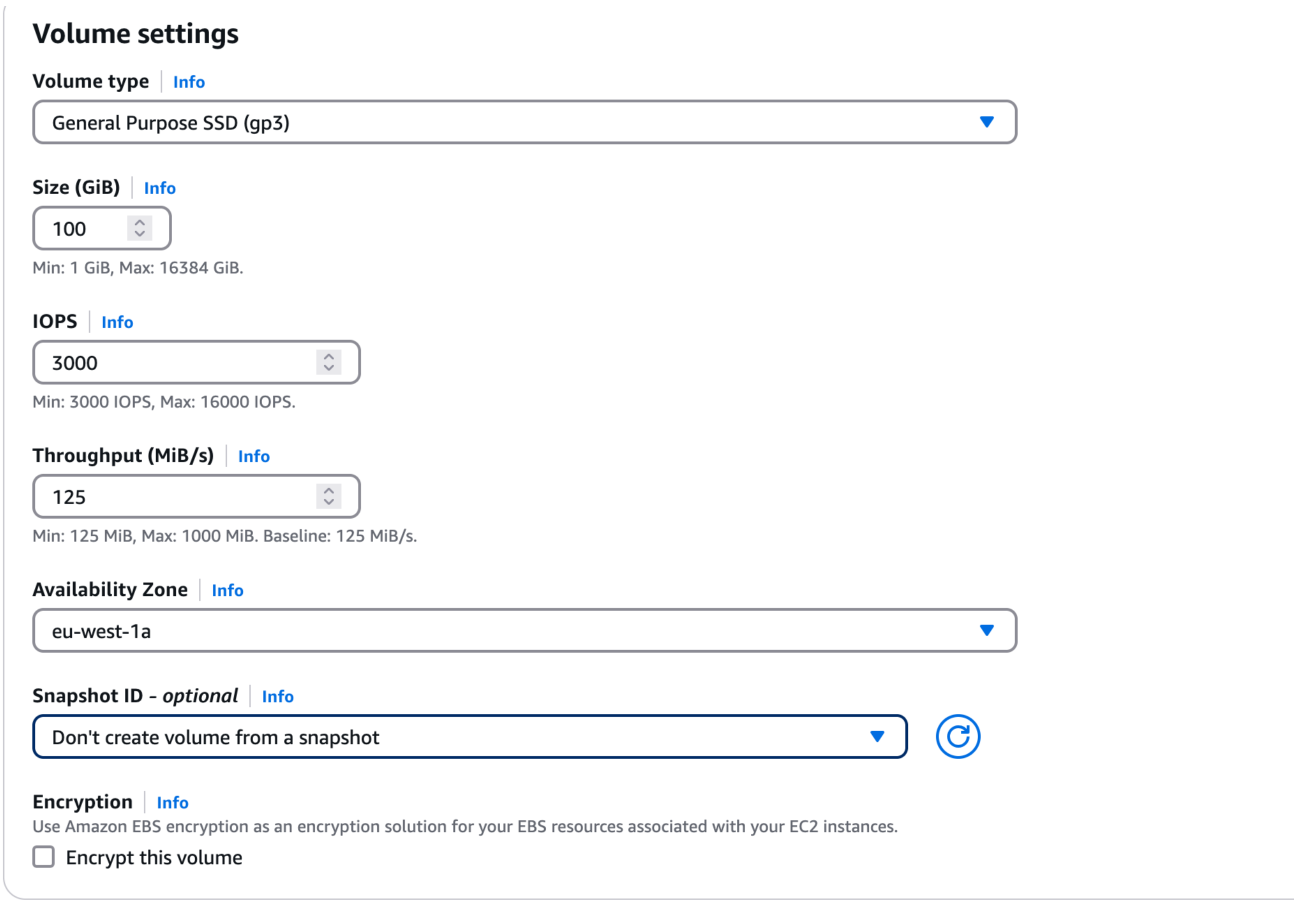
2.4 Volume Configuration

2.4.1. Prerequisites

- You have an active `AWS` account with the necessary permissions to create a new volume.
- You have an existing Elastic Compute (`EC2`) instance, to attach the new volume.

2.4.2. Creating a new EBS Volume

There are several methods to create a new Elastic Block Storage (`EBS`) data volume, including using the `AWS CLI`, `AWS CloudFormation`, or the Management Console.



Volume settings

Volume type | Info
General Purpose SSD (gp3)

Size (GiB) | Info
100
Min: 1 GiB, Max: 16384 GiB.

IOPS | Info
3000
Min: 3000 IOPS, Max: 16000 IOPS.

Throughput (MiB/s) | Info
125
Min: 125 MiB, Max: 1000 MiB. Baseline: 125 MiB/s.

Availability Zone | Info
eu-west-1a

Snapshot ID - *optional* | Info
Don't create volume from a snapshot

Encryption | Info
Use Amazon EBS encryption as an encryption solution for your EBS resources associated with your EC2 instances.
☐ Encrypt this volume

Creating a new volume through the Management Console is simple and straightforward. You can configure the following options:

`Volume type` Select the type of volume you want to use. The available options are listed here

`Size (GB)` The storage capacity in gigabytes available on the drive. The default value is 100 GB, but you can configure `EBS` volumes ranging from 1 GB to 16,384 GB. `EBS` costs are based on the amount of storage you provision, not on how much you actually use. For example, if you provision a 30 GB `EBS` volume but only use 5 GB, you'll still being charged for the entire 30 GB.

`IOPS` The number of operations per second (`IOPS`) the volume can support. By default, this value is set to 3,000, which is also the minimum. You can adjust this up to 16,000 `IOPS` for `gp3` volumes and up to 64,000 or 256,000 `IOPS` for `io1`/`io2` volumes, depending on the volume size.

`Throughput` The throughput performance the volume can handle. The default value is set to 125 MB/

s, but you can increase it up to 1,000 MB/s based on the amount of `IOPS` you provision. The throughput rate is 0.25 MB/s for each additional `IOPS`.

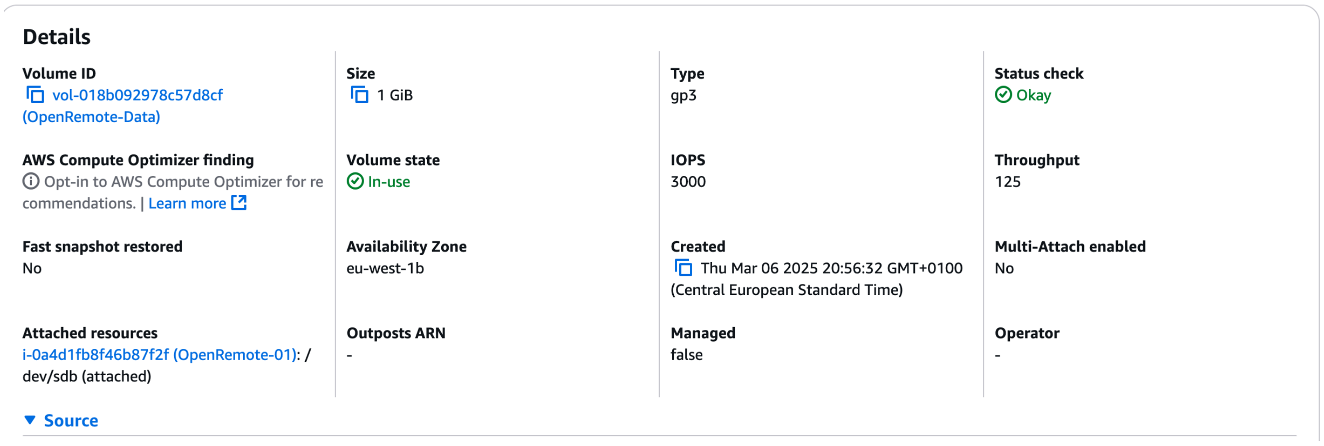
`Availability Zone` The `availability zone` where the volume is being created. The number of available AZs depends on the region where you're creating the volume. To ensure data durability and prevent failures, volumes are replicated within their respective `Availability Zone`. To attach an `EBS` volume to an `EC2` instance, the instance must be located in the same `Availability Zone` as the volume.

`Snapshot ID` If you want to create a volume from an existing snapshot, you can select the `Snapshot ID` during volume creation. The data from the snapshot will be available immediately.

`Encryption` You have the option to encrypt the volume. Amazon `EBS` encryption uses the Advanced Encryption Standard (AES-256) algorithm along with Amazon's Key Management Service (`KMS`). You can either use the default encryption key or create your own. Using your own key provides greater flexibility, including the ability to create, rotate, disable, and define access controls and security audits.

It is also possible to create `EBS` volumes while launching an `EC2` instance. These volumes are automatically attached to the instance.

2.4.3. Attach Volume to an EC2 Instance

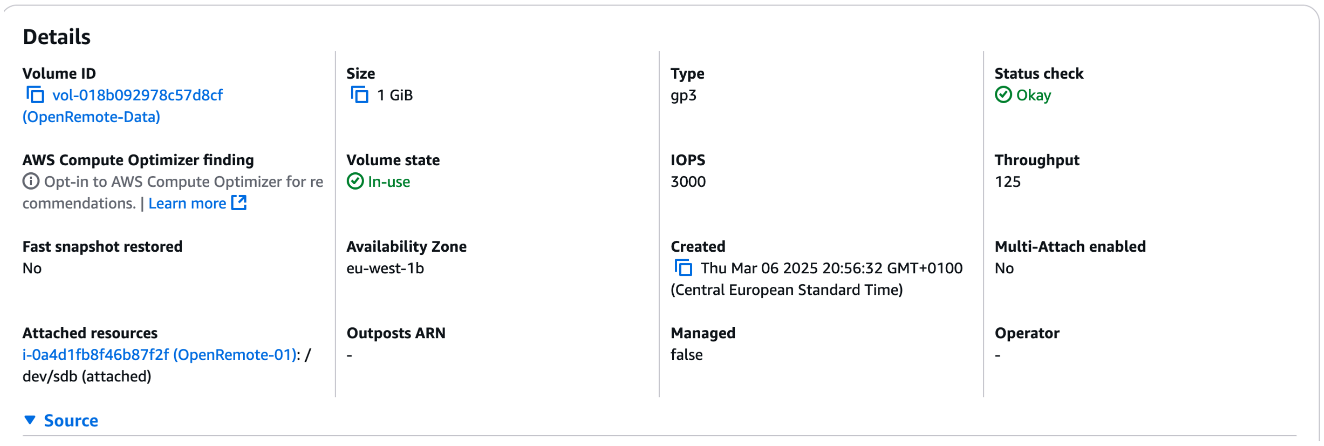


Details

Volume ID vol-018b092978c57d8cf (OpenRemote-Data)	**Size** 1 GiB	**Type** gp3	**Status check** Okay
AWS Compute Optimizer finding Opt-in to AWS Compute Optimizer for recommendations. | Learn more	**Volume state** In-use	**IOPS** 3000	**Throughput** 125
Fast snapshot restored No	**Availability Zone** eu-west-1b	**Created** Thu Mar 06 2025 20:56:32 GMT+0100 (Central European Standard Time)	**Multi-Attach enabled** No
Attached resources i-0a4d1fb8f46b87f2f (OpenRemote-01): /dev/sdb (attached)	**Outposts ARN** -	**Managed** false	**Operator** -

▼ Source

After creating an EBS volume, you can attach it to an EC2 instance. Data volumes can be attached to either running or stopped instances, while root volumes can only be attached or detached when the instance is fully stopped. You can only attach volumes that are in the available state. You can check the status on the details page for each individual volume.



Details

Volume ID vol-018b092978c57d8cf (OpenRemote-Data)	**Size** 1 GiB	**Type** gp3	**Status check** Okay
AWS Compute Optimizer finding Opt-in to AWS Compute Optimizer for recommendations. | Learn more	**Volume state** In-use	**IOPS** 3000	**Throughput** 125
Fast snapshot restored No	**Availability Zone** eu-west-1b	**Created** Thu Mar 06 2025 20:56:32 GMT+0100 (Central European Standard Time)	**Multi-Attach enabled** No
Attached resources i-0a4d1fb8f46b87f2f (OpenRemote-01): /dev/sdb (attached)	**Outposts ARN** -	**Managed** false	**Operator** -

▼ Source

To attach a volume to an instance, you need to configure the following options:

`Instance type` Choose the instance to which you want to attach the volume. Only instances located in the same availability zone as the EBS volume will be displayed.

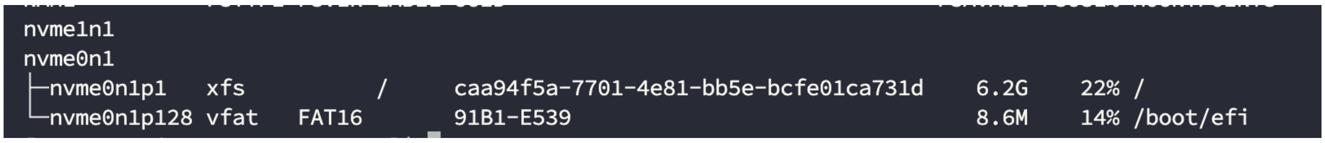
`Device name` Select a device name for the EBS volume. Data volumes typically use names like `/dev/sd[a-z]`, with names between `/dev/sd[f-p]` being recommended. Root volumes generally use the default `/dev/xvda` name. Each device name can only be used once.

2.4.4. Create Filesystem on Volume

Before an EBS volume can be used, it must be formatted and have a filesystem on it. Start by running the command below to list all existing block devices on the host machine.

```
sudo lsblk -f
```

As shown in the image below, the device is recognized, but it does not yet have a filesystem or a mountpoint.

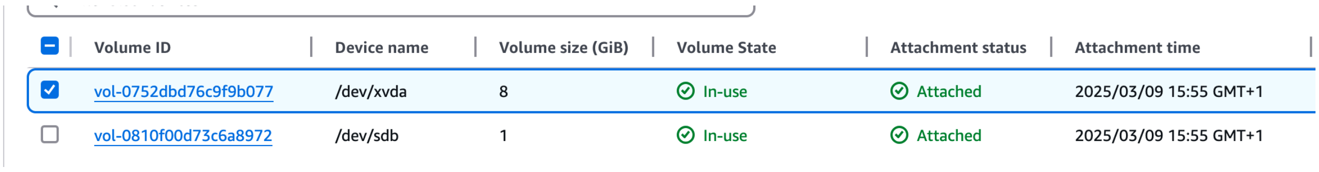


```
nvme1n1
nvme0n1
├─nvme0n1p1   xfs          /     caa94f5a-7701-4e81-bb5e-bcfe01ca731d    6.2G    22% /
└─nvme0n1p128 vfat   FAT16       91B1-E539                               8.6M    14% /boot/efi
```

To create a filesystem, use the command below.

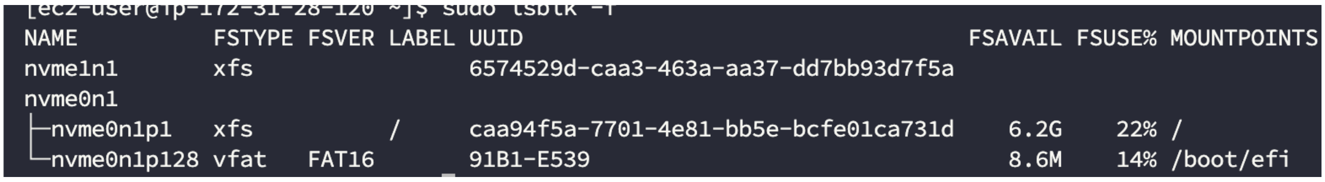
```
sudo mkfs -t xfs /dev/sdb
```

This command creates an XFS filesystem on the device named `/dev/sdb`. You cannot use the name visible in the `lsblk` output. Instead, you need to use the device name assigned during the EBS volume creation. The device names can be found under the storage tab on the details page of the specific EC2 instance.



	Volume ID	Device name	Volume size (GiB)	Volume State	Attachment status	Attachment time
✓	vol-0752dbd76c9f9b077	/dev/xvda	8	✓ In-use	✓ Attached	2025/03/09 15:55 GMT+1
☐	vol-0810f00d73c6a8972	/dev/sdb	1	✓ In-use	✓ Attached	2025/03/09 15:55 GMT+1

XFS is one of the filesystems you can use, but you can also choose others like `ext3`, `ext4`, and more. Since the root device is also using the XFS filesystem, it's recommended to stick with the same for consistency. After creating the filesystem, run the `lsblk` command again to verify if the filesystem appears in the list.



```
[ec2-user@ip-172-31-28-120 ~]$ sudo lsblk -f
NAME          FSTYPE FSVER LABEL UUID                                 FSAVAIL FSUSE% MOUNTPOINTS
nvme1n1       xfs                6574529d-caa3-463a-aa37-dd7bb93d7f5a
nvme0n1
├─nvme0n1p1   xfs          /     caa94f5a-7701-4e81-bb5e-bcfe01ca731d    6.2G    22% /
└─nvme0n1p128 vfat   FAT16       91B1-E539                               8.6M    14% /boot/efi
```

As shown in the picture above, the filesystem has been created successfully, and the device now has an assigned UUID. It is recommended to copy the device's UUID and store it in a safe place, as you will need it in a later step.

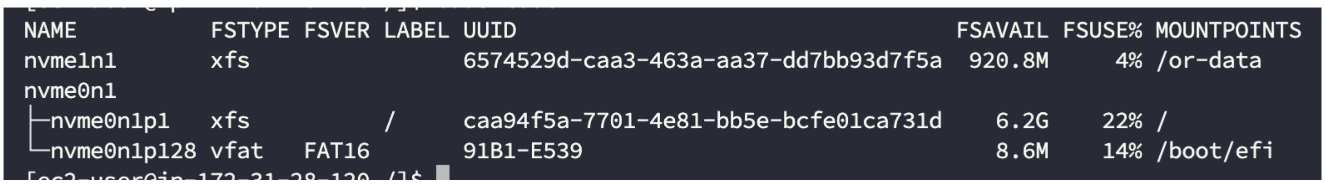
2.4.5. Mount Volume to directory

Once you have successfully formatted the volume and created a filesystem, you can mount the volume to a directory using the following command:

```
sudo mount /dev/sdb /or-data
```

You need to specify the device name assigned during `EBS` volume creation. You can mount the volume to any directory of your choice. The directory must already exist at the root of the host before you can mount the volume. The command will not create the specified directory for you. If the directory does not exist, the command will throw an error.

After mounting the volume, you can check the status with the `lsblk` command. If the device is successfully mounted, you should see the directory in the list, along with the remaining capacity and the amount of storage used.



```
NAME           FSTYPE FSVER LABEL UUID                                 FSAVAIL FSUSE% MOUNTPOINTS
nvme1n1        xfs                6574529d-caa3-463a-aa37-dd7bb93d7f5a  920.8M     4% /or-data
nvme0n1
├─nvme0n1p1    xfs          /     caa94f5a-7701-4e81-bb5e-bcfe01ca731d    6.2G    22% /
└─nvme0n1p128  vfat   FAT16       91B1-E539                               8.6M    14% /boot/efi
```

2.4.6. Automatically mount volume on system reboot

To make sure that the volume is mounted after a system reboot. You need to add a line in the `/etc/fstab/` file. This is the `System File Table` and stores information about the drives. Making changes in this file is dangerous and can cause boot errors if the file is corrupted or incorrect. Please make a back-up before editing this file.

To create a backup from this file you can enter the following command.

```
sudo cp /etc/fstab /etc/fstab.orig
```

This command copies the file from the `/etc/fstab` location and places it in the same folder with a different extension. Once the backup is successfully created, you can add the new volume to the file table. There are two convenient ways to achieve this:

- By using a text editor such as `VIM` or `GNU Nano`.
- By using the command line to directly insert the appropriate row.

The entry has a few parameters that needs to exists:

`UUID` The first parameter is the device `UUID`, which is visible when executing the `lsblk` command. You can also retrieve the `UUID` using the following command.

```
sudo blkid
```

`Directory` The second parameter is the directory where the volume needs to be mounted. This directory must already exist, as the system cannot create directories automatically.

`Filesystem Type` The third parameter is the filesystem type. In most cases, this is `XFS`, but the value depends on the filesystem you selected during the initial volume setup.

`Flags` The fourth parameter consists of device `flags`. While there are many different `flags`, the most commonly used is the `defaults` flag. This includes several options, such as:

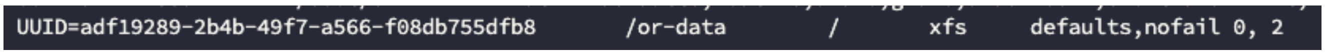
- `rw`: Allows reading and writing
- `suid`: Enables special security bits
- `dev`: Enables block-special devices
- `exec`: Permits execution of binaries
- `auto`: Enables automatic mounting
- `nouser`: Restricts mounting to the root user only
- `async`: Allows asynchronous I/O

The `nofail` flag is also often used to ensure that the system does not fail on boot if a specified device or mountpoint is unavailable.

`Dump` The fifth parameter determines whether the filesystem should be backed up using the `dump` command. The value can be either `1` (yes) or `0` (no).

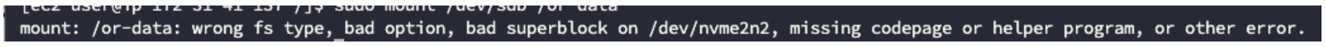
`Device type` The last parameter determines whether the device is a `root` or `non-root` device. The value can be either `1` (for root) or `2` (for non-root).

When you succesfully created the entry in the `/etc/fstab` file, it should look like this



```
UUID=adf19289-2b4b-49f7-a566-f08db755dfb8       /or-data        /       xfs     defaults,nofail 0, 2
```

If this entry is not created, the system will not only skip mounting the volume on reboot, but it can also result in mount errors when the volume is attached to another `EC2` instance. This happens because device names can change depending on the machine, but the `UUID` remains consistent throughout the volume's lifespan. If the system detects that you are attempting to mount the volume that was previously mounted to a different device name, the following error will be thrown:



```
mount: /or-data: wrong fs type, bad option, bad superblock on /dev/nvme2n2, missing codepage or helper program, or other error.
```

You can ignore the error and mount the volume anyway with the following command:

```
sudo mount -o nouuid /dev/sdb /or-data
```

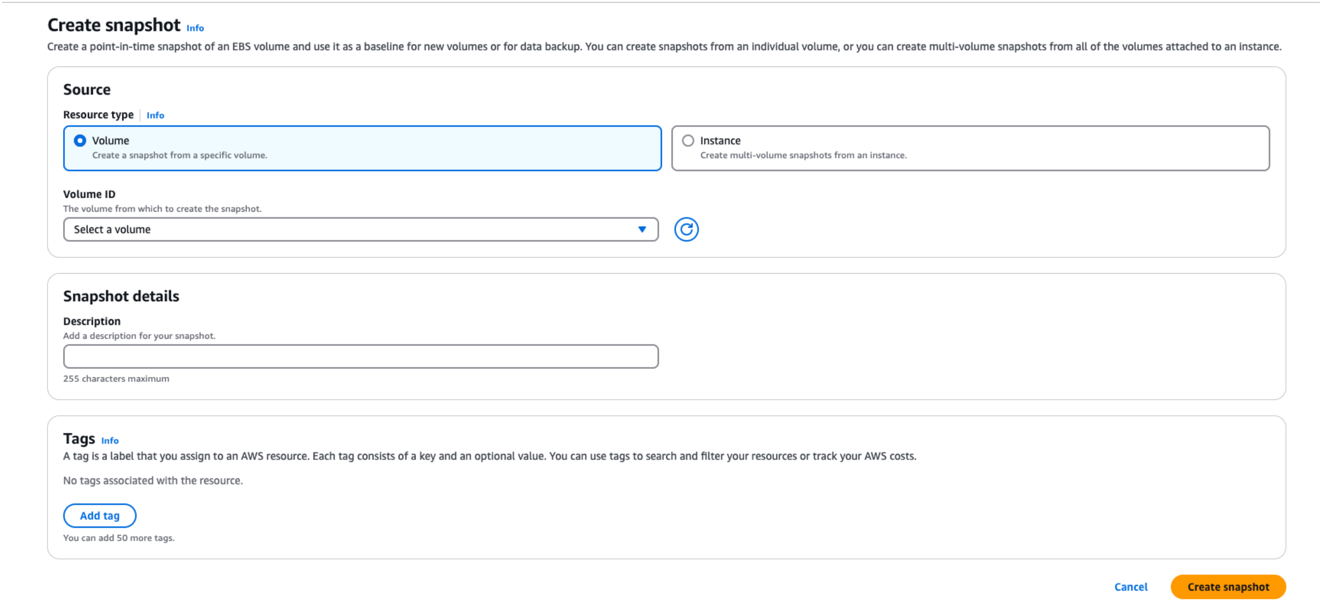
Creating the `fstab` entry ensures that the device is mounted using its `UUID`, preventing errors when it is connected to another `EC2` instance, even if the device name differs.

2.5. EBS Snapshots

This section explains how `snapshots` (backups) can be created/restored with the built-in snapshot functionality.

2.5.1. Manually creating snapshots

You can create snapshots on specific `EBS` volumes and on instance level. To create a snapshot via the management console, You need to configure the following options:


Create snapshot Info

Create a point-in-time snapshot of an EBS volume and use it as a baseline for new volumes or for data backup. You can create snapshots from an individual volume, or you can create multi-volume snapshots from all of the volumes attached to an instance.

Source

Resource type | Info

[✓ Volume — Create a snapshot from a specific volume.] Instance — Create multi-volume snapshots from an instance.

Volume ID
The volume from which to create the snapshot.
Select a volume

Snapshot details

Description
Add a description for your snapshot.

255 characters maximum

Tags Info

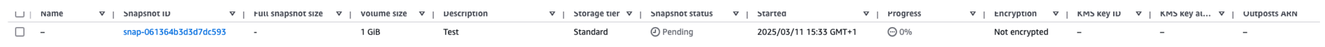
A tag is a label that you assign to an AWS resource. Each tag consists of a key and an optional value. You can use tags to search and filter your resources or track your AWS costs.

No tags associated with the resource.

You can add 50 more tags.

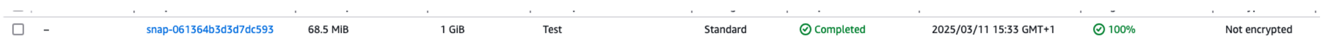
- `Source`: You can choose between `volumes` and `instances` when creating a snapshot. When creating a snapshot from an instance, you still have the option to exclude the root device or specific data volumes.
- `Volume/Instance ID`: Depending on the source, you will need to select either the `Volume ID` or `Instance ID` for which you want to create the snapshot.
- `Description`: You have the option to provide a description for the snapshot to make it easier to recognize.

When the snapshot is being created, It will show the `pending` status on the overview page. Creating snapshots can take between 5 min and several hours depending on the volume size.



	Name	Snapshot ID	Full snapshot size	Volume size	Description	Storage tier	Snapshot status	Started	Progress	Encryption	KMS key ID	KMS key al...	Outposts ARN
☐	–	snap-061364b3d3d7dc593	-	1 GiB	Test	Standard	Pending	2025/03/11 15:33 GMT+1	0%	Not encrypted	–	–	–

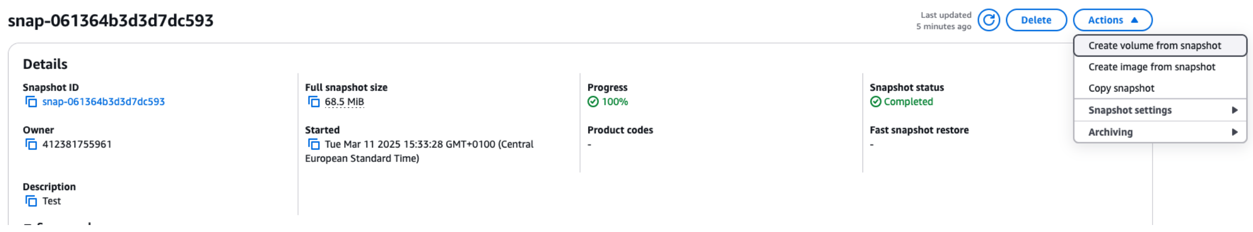
After the snaphot is successfully created you will see the `complete` status on the overview page.



☐	–	snap-061364b3d3d7dc593	68.5 MiB	1 GiB	Test	Standard	✓ Completed	2025/03/11 15:33 GMT+1	✓ 100%	Not encrypted

2.5.2. Restoring snapshots

To restore a snapshot, you can choose to either create a new volume or an `AMI` (Amazon Machine Image), which can then be used to launch a new instance.



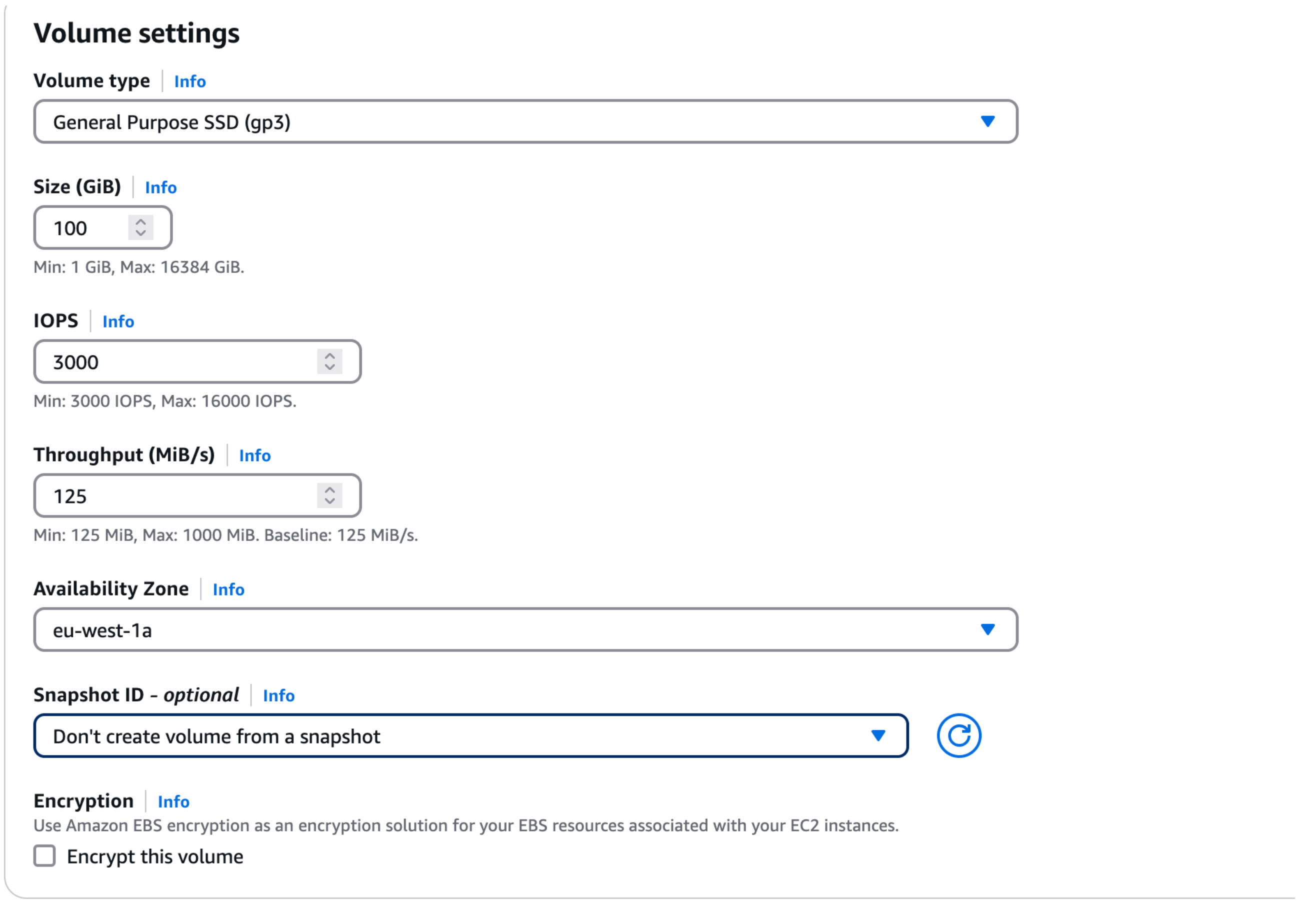
snap-061364b3d3d7dc593

Details

Snapshot ID snap-061364b3d3d7dc593	**Full snapshot size** 68.5 MiB	**Progress** 100%	**Snapshot status** Completed
Owner 412381755961	**Started** Tue Mar 11 2025 15:33:28 GMT+0100 (Central European Standard Time)	**Product codes** -	**Fast snapshot restore** -
Description Test			

Last updated 5 minutes ago
Delete
Actions
Create volume from snapshot
Create image from snapshot
Copy snapshot
Snapshot settings
Archiving

You can configure the volume in the same way as you would when creating a new volume, but by specifying a `Snapshot ID`. Once the volume is created, you can attach and mount it to an `EC2` instance. The data from the snapshot will be immediately available.



Volume settings

Volume type	General Purpose SSD (gp3)
Size (GiB)	100 (Min: 1 GiB, Max: 16384 GiB.)
IOPS	3000 (Min: 3000 IOPS, Max: 16000 IOPS.)
Throughput (MiB/s)	125 (Min: 125 MiB, Max: 1000 MiB. Baseline: 125 MiB/s.)
Availability Zone	eu-west-1a
Snapshot ID - *optional*	Don't create volume from a snapshot
Encryption	Use Amazon EBS encryption as an encryption solution for your EBS resources associated with your EC2 instances. ☐ Encrypt this volume

<

2.5.3. Pricing

Pricing varies based on the region where the resources are deployed. Since OpenRemote uses `eu-west-1` as their primary region, the prices listed below will apply on this. `EBS` snapshot pricing is very simple and only has a few different options:

- `Standard Pricing`: $0,05/GB per month
- `Archive Pricing`: $0,0125/GB per month

The pricing above reflects storage costs. There are no charges for restoring snapshots. However, restoring data from archive will incur a cost of $0.03 per GB of data retrieved.

If snapshots are created with the `Fast Snapshot Restore` option enabled, you are charged in `Data Service Units (DSU)` with a minimum charge of one hour. These charges continue as long as the option remains enabled for the snapshot, which can increase your bill quickly. Therefore, it's recommended to enable this feature only when absolutely necessary. The DSU pricing for `eu-west-1` is $0.83 per 1 DSU hour for each snapshot with this feature enabled in a specific `availability zone`.

When creating a volume from a snapshot with `Fast Snapshot Restore` enabled, it will immediately deliver all its provisioned performance `(IOPS)`, eliminating the latency usually associated with I/O operations when accessing the volume for the first time. This ensures that the volume is fully initialized upon creation.

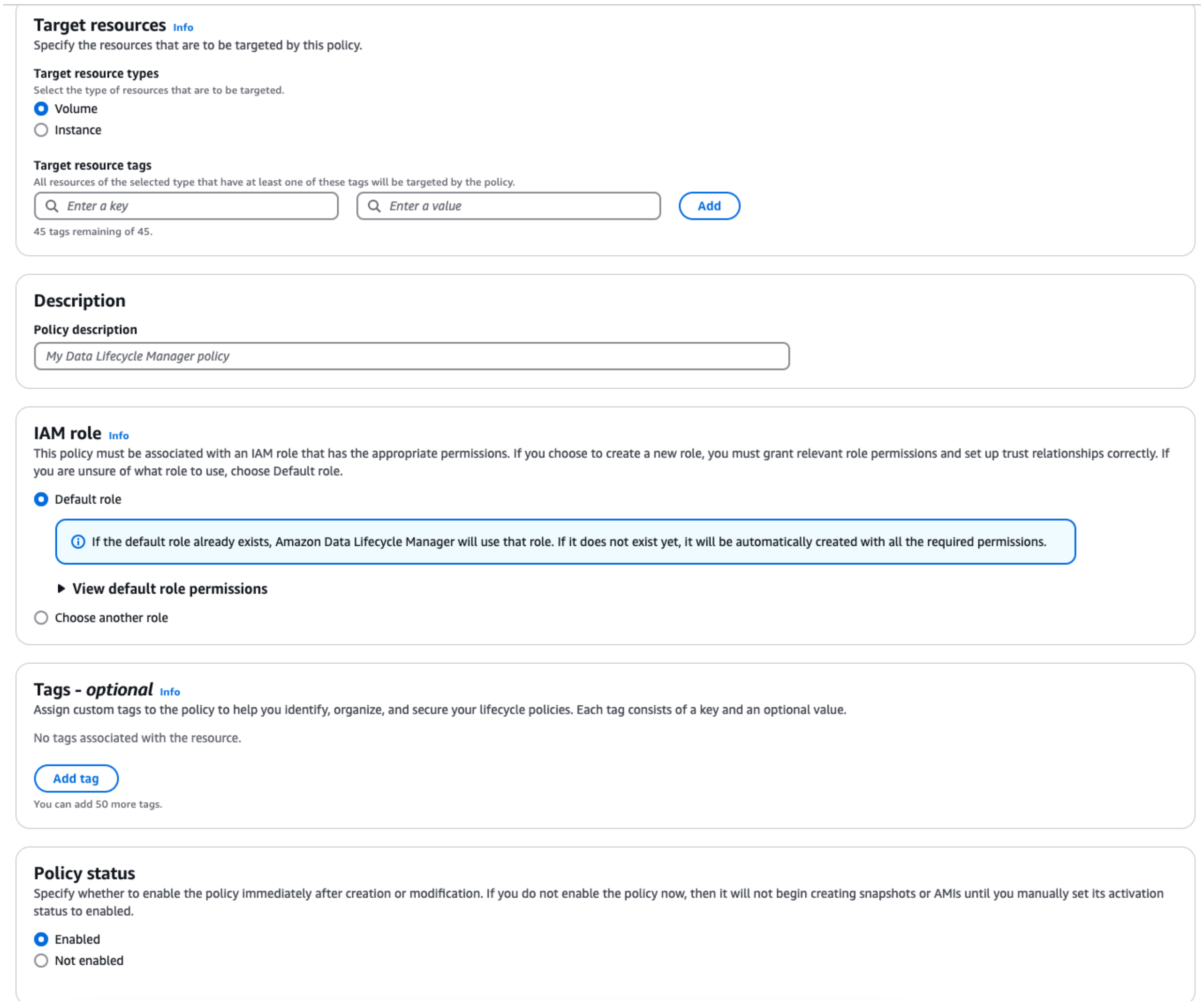
2.6. Amazon Data Lifecycle Manager

To automate snapshot creation, retention, and deletion, you can use `Amazon Data Lifecycle Manager`. With this tool, you can configure policies that define when snapshots are created and from which resources. You can also specify how frequently the policy should be executed. Additionally, it allows you to run scripts before or after snapshot creation, automatically copy snapshots to other regions or accounts, and even set rules for snapshot retention and archiving.

2.6.1. Creating policies

To create a policy you can either choose between two different options:

- `Default Policy`: The default policy is simple and can only be used to create snapshots from volumes. Customization options are limited. it's not possible to target specific volumes or instances. Retention settings can only be configured with a maximum of `14` days, and snapshot creation can be scheduled between `1` and `7` days. Additional features such as `fast snapshot restore`, `archiving`, and `sharing` are not available when using this policy.
- `Custom Policy`: With a custom policy, there are no limits. You can target volumes and instances based on tags. It allows up to `4` different schedules, which can run at any time using a cron expression. Advanced features such as `archiving`, `deletion`, `sharing`, and `running scripts` are also available with this option.


Target resources Info
Specify the resources that are to be targeted by this policy.

Target resource types
Select the type of resources that are to be targeted.
[✓ Volume]
Instance

Target resource tags
All resources of the selected type that have at least one of these tags will be targeted by the policy.
Enter a key | Enter a value | Add
45 tags remaining of 45.

Description
Policy description
My Data Lifecycle Manager policy

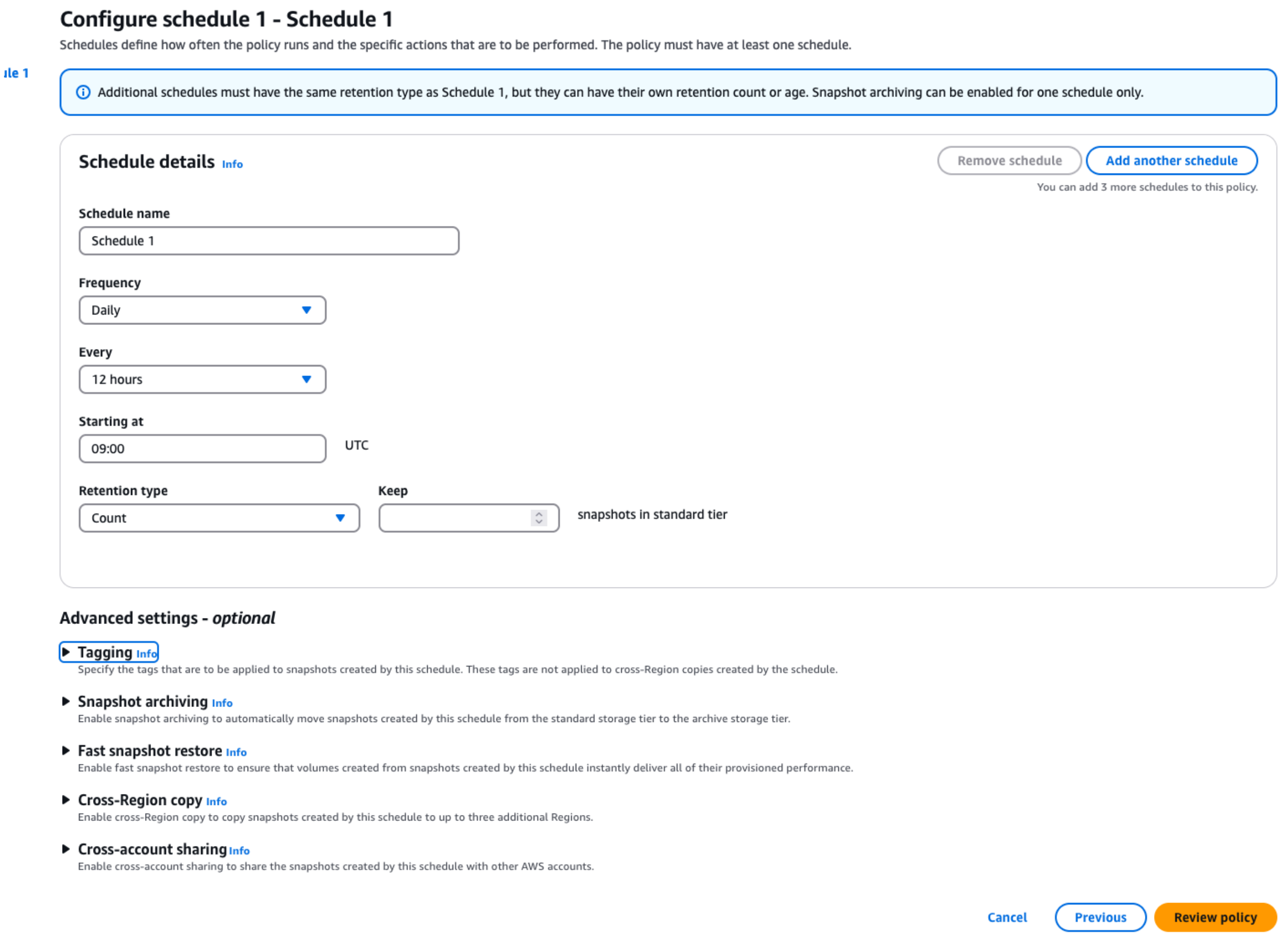
IAM role Info
This policy must be associated with an IAM role that has the appropriate permissions. If you choose to create a new role, you must grant relevant role permissions and set up trust relationships correctly. If you are unsure of what role to use, choose Default role.
[✓ Default role]
If the default role already exists, Amazon Data Lifecycle Manager will use that role. If it does not exist yet, it will be automatically created with all the required permissions.
▸ View default role permissions
Choose another role

Tags - *optional* Info
Assign custom tags to the policy to help you identify, organize, and secure your lifecycle policies. Each tag consists of a key and an optional value.
No tags associated with the resource.
Add tag
You can add 50 more tags.

Policy status
Specify whether to enable the policy immediately after creation or modification. If you do not enable the policy now, then it will not begin creating snapshots or AMIs until you manually set its activation status to enabled.
[✓ Enabled]
Not enabled

In this example, I have created a `Custom Policy` because it offers more flexibility and is better suited to the needs of OpenRemote. To create an `Custom Policy` within the management console, you need to configure the following options:

- `Target resource types`: You can either choose between volumes or instances. You can then specify which resource you want to select based on different tags such as name and id.
- `Description`: You can enter a description to easy identify the policy.
- `IAM Role`: To create snapshots, Lifecycle Manager must have the approriate permissions. You can either select an existing `IAM` role or use the default one. If Lifecycle Manager has insufficient permissions, the snapshot process will throw an error.
- `Policy status`: You can specify if you want to enable this policy after creation. By doing so, Lifecycle Manager wil start the creation of snapshots inmmediately according to the configured schedule.
- `Exclude devices`: If you have selected the instance as an resource type, you have additionaly the option to exclude the root volume or specfic data volumes that are attached to the `EC2` instance.


Configure schedule 1 - Schedule 1

Schedules define how often the policy runs and the specific actions that are to be performed. The policy must have at least one schedule.

Additional schedules must have the same retention type as Schedule 1, but they can have their own retention count or age. Snapshot archiving can be enabled for one schedule only.

Schedule details

You can add 3 more schedules to this policy.

Schedule name	Schedule 1
Frequency	Daily
Every	12 hours
Starting at	09:00 UTC
Retention type	Count
Keep	snapshots in standard tier

Advanced settings - *optional*

- Tagging: Specify the tags that are to be applied to snapshots created by this schedule. These tags are not applied to cross-Region copies created by the schedule.
- Snapshot archiving: Enable snapshot archiving to automatically move snapshots created by this schedule from the standard storage tier to the archive storage tier.
- Fast snapshot restore: Enable fast snapshot restore to ensure that volumes created from snapshots created by this schedule instantly deliver all of their provisioned performance.
- Cross-Region copy: Enable cross-Region copy to copy snapshots created by this schedule to up to three additional Regions.
- Cross-account sharing: Enable cross-account sharing to share the snapshots created by this schedule with other AWS accounts.

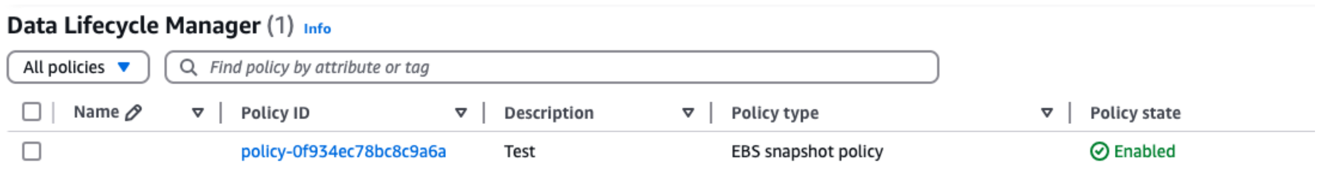
After that, you can create a schedule to specify how often the snapshots should be created. With a `Custom Policy`, you can configure up to `4` different schedules. At this stage, you can also set the retention period, determining how long the snapshots will persist. This can be specified either as a number of days or based on the number of recurring snapshots.

Optionally, You can configure a few advanced settings such as:

- `Tags`: You can specify tags that need to apply on a specifc snapshot, or you can simply copy the tags from the resource.

- `Snapshot archiving`: You can specify if the snapshot needs to be archived, this setting is only available when the schedule creates an snapshot at least every `28` days.
- `Fast Snapshot Restore`: You can specify if fast snapshot restore needs to be enabled for the snapshots that are being created by this policy. Fast Snapshot restore is expensive, so only enable this feature when it's really necessary
- `Cross Region Copy`: You can specify if the snapshot needs to be copied to other regions. You can copy snapshots up to `3` different regions.
- `Cross Account Copy`: You can specify the AWS Account IDS with who you want to share the snapshots created with this policy.
- `Pre/post scripts`: If you have selected instance as an resource type, you can specify which scripts need to be executed on the `EC2` machine before and after snapshot creation.

Once you have successfully created the policy, it will appear in the list. Based on the policy status, it will immediately begin executing according to the schedule you provided.


Data Lifecycle Manager (1) Info
All policies
Find policy by attribute or tag

Name	Policy ID	Description	Policy type	Policy state
	policy-0f934ec78bc8c9a6a	Test	EBS snapshot policy	Enabled

3. Prototyping

In this section I will explain how I configured the OpenRemote software to use the seperate EBS volume for storing the IoT data.

3.1. Docker Compose

OpenRemote uses a `Docker Compose` file to define the `containers` and their settings that need to be started within `Docker`. The default file looks like this:

```
# OpenRemote v3
#
# Profile that runs the stack by default on https://localhost using a
self-signed SSL certificate,
# but optionally on https://$OR_HOSTNAME with an auto generated SSL
certificate from Letsencrypt.
#
# It is configured to use the AWS logging driver.
#
volumes:
  proxy-data:
  manager-data:
  postgresql-data:

services:

  proxy:
    image: openremote/proxy:${PROXY_VERSION:-latest}
    restart: always
    depends_on:
      manager:
        condition: service_healthy
    ports:
      - "80:80" # Needed for SSL generation using letsencrypt
      - "${OR_SSL_PORT:-443}:443"
      - "8883:8883"
      - "127.0.0.1:8404:8404" # Localhost metrics access
    volumes:
      - proxy-data:/deployment
    environment:
      LE_EMAIL: ${OR_EMAIL_ADMIN:-}
      DOMAINNAME: ${OR_HOSTNAME:-localhost}
      DOMAINNAMES: ${OR_ADDITIONAL_HOSTNAMES:-}
      # USE A CUSTOM PROXY CONFIG - COPY FROM https://
raw.githubusercontent.com/openremote/proxy/main/haproxy.cfg
      #HAPROXY_CONFIG: '/data/proxy/haproxy.cfg'

  postgresql:
    restart: always
    image: openremote/postgresql:${POSTGRESQL_VERSION:-latest}
    shm_size: 128mb
    volumes:
      - postgresql-data:/var/lib/postgresql/data
      - manager-data:/storage

  keycloak:
    restart: always
    image: openremote/keycloak:${KEYCLOAK_VERSION:-latest}
    depends_on:
      postgresql:
        condition: service_healthy
    volumes:
      - ./deployment:/deployment
    environment:
      KEYCLOAK_ADMIN_PASSWORD: ${OR_ADMIN_PASSWORD:-secret}
      KC_HOSTNAME: ${OR_HOSTNAME:-localhost}
      KC_HOSTNAME_PORT: ${OR_SSL_PORT:--1}


  manager:
#    privileged: true
    restart: always
    image: openremote/manager:${MANAGER_VERSION:-latest}
    depends_on:
      keycloak:
        condition: service_healthy
    ports:
      - "127.0.0.1:8405:8405" # Localhost metrics access
    environment:
      OR_SETUP_TYPE:
      OR_ADMIN_PASSWORD:
      OR_SETUP_RUN_ON_RESTART:
      OR_EMAIL_HOST:
      OR_EMAIL_USER:
      OR_EMAIL_PASSWORD:
      OR_EMAIL_X_HEADERS:
      OR_EMAIL_FROM:
      OR_EMAIL_ADMIN:
      OR_METRICS_ENABLED: ${OR_METRICS_ENABLED:-true}
      OR_HOSTNAME: ${OR_HOSTNAME:-localhost}
      OR_ADDITIONAL_HOSTNAMES:
      OR_SSL_PORT: ${OR_SSL_PORT:--1}
      OR_DEV_MODE: ${OR_DEV_MODE:-false}

      # The following variables will configure the demo
      OR_FORECAST_SOLAR_API_KEY:
      OR_OPEN_WEATHER_API_APP_ID:
      OR_SETUP_IMPORT_DEMO_AGENT_KNX:
      OR_SETUP_IMPORT_DEMO_AGENT_VELBUS:
    volumes:
      - manager-data:/storage
```

As below above, several volumes are declared at the top of the `Docker Compose` file. These are `named` volumes, which are used to store data from the containers.

```
volumes:
  proxy-data:
  manager-data:
  postgresql-data:
```

In the `volumes` block within a specifc container you can map a directory to either a named `volume` (that's declared at the top) or an other directory `(bind mount)`.

```
volumes:
 - postgresql-data:/var/lib/postgresql/data
 - manager-data:/storage
```

In the example above, the directory `/var/lib/postgresql/data` is mounted to the `named` volume `postgresql-data`. These named volumes are automatically created by `Docker` during the execution of the `Docker Compose` file.

If no additional options are configured, the `volumes` will be stored in the default `Docker` location at `/var/lib/docker/volumes/`. This location is stored on the default (root) `EBS` volume. To decouple the data, the location where these files are saved needs to be changed.

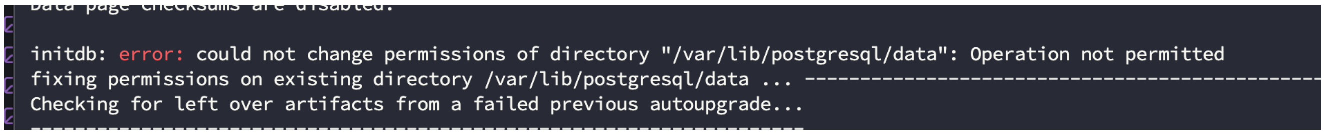
In my approach, I aim to make the solution as modular as possible, ensuring that it is easy for others to modify these values for their own OpenRemote configuration.

3.2. Approach 1 (Bind Mount)

In my first approach, I tried to replace the `named` volumes with the directory that is mounted on the seperate `EBS` volume. This way, the data will be stored directly on the seperate block device.

```
    volumes:
      - /or-data:/deployment
```

Unfortunately, this approach wasn't successful as I encountered various issues related to permissions. The `PostgresSQL container` couldn't start because it has insuficcient permissions.



```
Data page checksums are disabled.

initdb: error: could not change permissions of directory "/var/lib/postgresql/data": Operation not permitted
fixing permissions on existing directory /var/lib/postgresql/data ... ---------------------------------------------
Checking for left over artifacts from a failed previous autoupgrade...
```

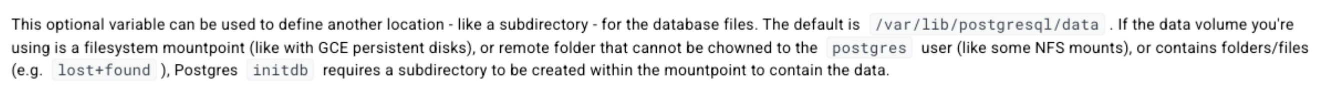
After investigating the issue I tried to give the `postgres` user the required permissions with the following command:

```
sudo chown -R 999:999 /or-data
```

The `uid` and `gid` with the number 999 refer to the `postgres` user, granting it access to the `/or-data` directory, which is mounted to the new `EBS` volume. Unfortunately, this didn't solve the problem. I encountered some inconsistencies when using this command in combination with the command below.

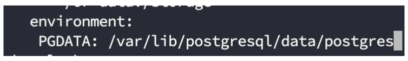
```
sudo chmod -R 777 /or-data
```

This command grants full permissions (`777`) to the `/or-data` directory for read/write operations. While combining these commands sometimes resolves the issue, the problem reoccurs after rebooting the machine or the containers. I continued my investigation and found an interesting note in the `PostgreSQL` documentation on `Dockerhub`



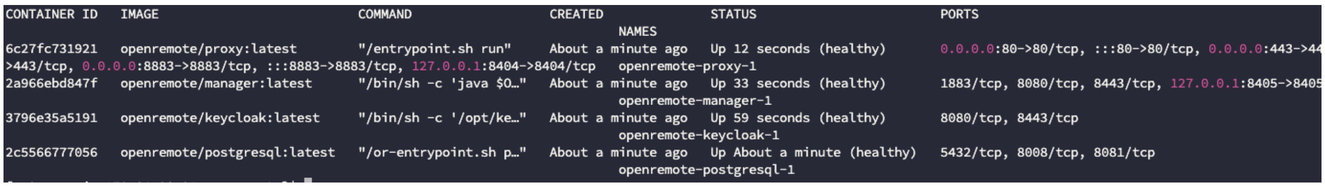
This optional variable can be used to define another location - like a subdirectory - for the database files. The default is `/var/lib/postgresql/data`. If the data volume you're using is a filesystem mountpoint (like with GCE persistent disks), or remote folder that cannot be chowned to the `postgres` user (like some NFS mounts), or contains folders/files (e.g. `lost+found`), Postgres `initdb` requires a subdirectory to be created within the mountpoint to contain the data.

They describe the exact problem I encountered and resolve it by overriding the default `Postgres` data location, using the `PGDATA environment` variable within the `container`.



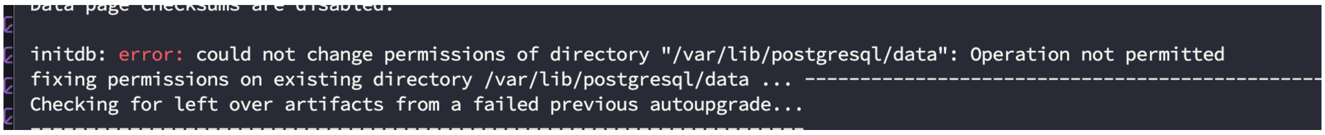
```
environment:
  PGDATA: /var/lib/postgresql/data/postgres
```

After saving the `Docker Compose` file and rebuilding the containers, all the `containers` started without any issues, and OpenRemote is now accessible via the `Public IP`.



```
CONTAINER ID   IMAGE                        COMMAND                  CREATED              STATUS                     PORTS
                                                                               NAMES
6c27fc731921   openremote/proxy:latest      "/entrypoint.sh run"     About a minute ago   Up 12 seconds (healthy)    0.0.0.0:80->80/tcp, :::80->80/tcp, 0.0.0.0:443->44
>443/tcp, 0.0.0.0:8883->8883/tcp, :::8883->8883/tcp, 127.0.0.1:8404->8404/tcp   openremote-proxy-1
2a966ebd847f   openremote/manager:latest    "/bin/sh -c 'java $0…"   About a minute ago   Up 33 seconds (healthy)    1883/tcp, 8080/tcp, 8443/tcp, 127.0.0.1:8405->8405
                                                                               openremote-manager-1
3796e35a5191   openremote/keycloak:latest   "/bin/sh -c '/opt/ke…"   About a minute ago   Up 59 seconds (healthy)    8080/tcp, 8443/tcp
                                                                               openremote-keycloak-1
2c5566777056   openremote/postgresql:latest "/or-entrypoint.sh p…"   About a minute ago   Up About a minute (healthy)   5432/tcp, 8008/tcp, 8081/tcp
                                                                               openremote-postgresql-1
```

Unfortunately, after detaching the `volume` and connecting it to a separate instance, the same permissions error occurred, even with the `PGDATA` variable added to the `Docker Compose` file. Despite resetting the permissions multiple times, the issue remained unresolved.



```
Data page checksums are disabled.

initdb: error: could not change permissions of directory "/var/lib/postgresql/data": Operation not permitted
fixing permissions on existing directory /var/lib/postgresql/data ... ---------------------------------------------
Checking for left over artifacts from a failed previous autoupgrade...
------------------------------------------------------------------------
```

I continued my investigation and attempted to add `subdirectories` for each `container` in the `Docker Compose` file, as shown below:

```
    volumes:
      - /or-data/proxy:-/deployment
```

This setup ensures that each `container` is restricted to writing only to its designated subdirectory, preventing multiple containers from writing to the same directory, such as `/or-data`, simultaneously. I tested this small change, and it resolves the permissions error. To make this approach more modular, I've added some `environment` variables.

```
# OpenRemote v3
#
# Profile that runs the stack by default on https://localhost using a
self-signed SSL certificate,
# but optionally on https://$OR_HOSTNAME with an auto generated SSL
certificate from Letsencrypt.
#
# It is configured to use the AWS logging driver.
#
volumes:
  proxy-data:
  manager-data:
  postgresql-data:

services:
  proxy:
    image: openremote/proxy:${PROXY_VERSION:-latest}
    restart: always
    depends_on:
      manager:
        condition: service_healthy
    ports:
      - 80:80 # Needed for SSL generation using letsencrypt
      - ${OR_SSL_PORT:-443}:443
      - 8883:8883
      - 127.0.0.1:8404:8404 # Localhost metrics access
    volumes:
      - ${OR_PROXY_PATH:-proxy-data}:/deployment
    environment:
      LE_EMAIL: ${OR_EMAIL_ADMIN:-}
      DOMAINNAME: ${OR_HOSTNAME:-localhost}
      DOMAINNAMES: ${OR_ADDITIONAL_HOSTNAMES:-}
      # HAPROXY_DATA_PATH: ${HAPROXY_DATA_PATH:-proxy-data}
      # USE A CUSTOM PROXY CONFIG - COPY FROM https://
raw.githubusercontent.com/openremote/proxy/main/haproxy.cfg
      # HAPROXY_CONFIG: '/data/proxy/haproxy.cfg'

  postgresql:
    restart: always
    image: openremote/postgresql:${POSTGRESQL_VERSION:-latest}
    shm_size: 128mb
    volumes:
      - ${OR_POSTGRES_PATH:-postgresql-data}:/var/lib/postgresql/data/
      - ${OR_MANAGER_PATH:-manager-data}:/storage
    environment:
     PGDATA: /var/lib/postgresql/data/postgres

  keycloak:
    restart: always
    image: openremote/keycloak:${KEYCLOAK_VERSION:-latest}
    depends_on:
      postgresql:
        condition: service_healthy
    volumes:
      - ${OR_KEYCLOAK_PATH:-./deployment}:/deployment
    environment:
      KEYCLOAK_ADMIN_PASSWORD: ${OR_ADMIN_PASSWORD:-secret}
      KC_HOSTNAME: ${OR_HOSTNAME:-localhost}
      KC_HOSTNAME_PORT: ${OR_SSL_PORT:--1}


  manager:
  # privileged: true
    restart: always
    image: openremote/manager:${MANAGER_VERSION:-latest}
    depends_on:
      keycloak:
        condition: service_healthy
    ports:
      - 127.0.0.1:8405:8405 # Localhost metrics access
    environment:
      OR_SETUP_TYPE:
      OR_ADMIN_PASSWORD:
      OR_SETUP_RUN_ON_RESTART:
      OR_EMAIL_HOST:
      OR_EMAIL_USER:
      OR_EMAIL_PASSWORD:
      OR_EMAIL_X_HEADERS:
      OR_EMAIL_FROM:
      OR_EMAIL_ADMIN:
      OR_METRICS_ENABLED: ${OR_METRICS_ENABLED:-true}
      OR_HOSTNAME: ${OR_HOSTNAME:-localhost}
      OR_ADDITIONAL_HOSTNAMES:
      OR_SSL_PORT: ${OR_SSL_PORT:--1}
      OR_DEV_MODE: ${OR_DEV_MODE:-false}
      # The following variables will configure the demo
      OR_FORECAST_SOLAR_API_KEY:
      OR_OPEN_WEATHER_API_APP_ID:
      OR_SETUP_IMPORT_DEMO_AGENT_KNX:
      OR_SETUP_IMPORT_DEMO_AGENT_VELBUS:
    volumes:
      - ${OR_MANAGER_PATH:-manager-data}:/storage
```

By adding these `variables`, you can define the storage location for each `container` in the startup command.

```
OR_HOSTNAME=<PUBLIC IP> OR_PROXY_PATH=/or-data/proxy OR_MANAGER_PATH=/
or-data/manager OR_POSTGRES_PATH=/or-data/postgres OR_KEYCLOAK_PATH=/or-
data/keycloak docker-compose -p openremote up -d
```

If no value is provided, `Docker` will use the default `named` volumes declared at the top and stores the information on the `root` device.

3.3. Approach 2 (Named volumes)

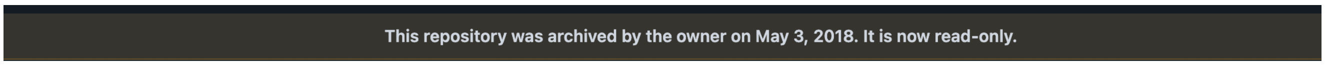
After the first succesful attempt, I continued my investigation by examining the existing `named` volumes in the `Docker Compose` file. These volumes are automatically created by Docker during the execution of the `Docker Compose` file. However, by adding the `external: true` property, `Docker` will not create the volume but instead look for an existing one.

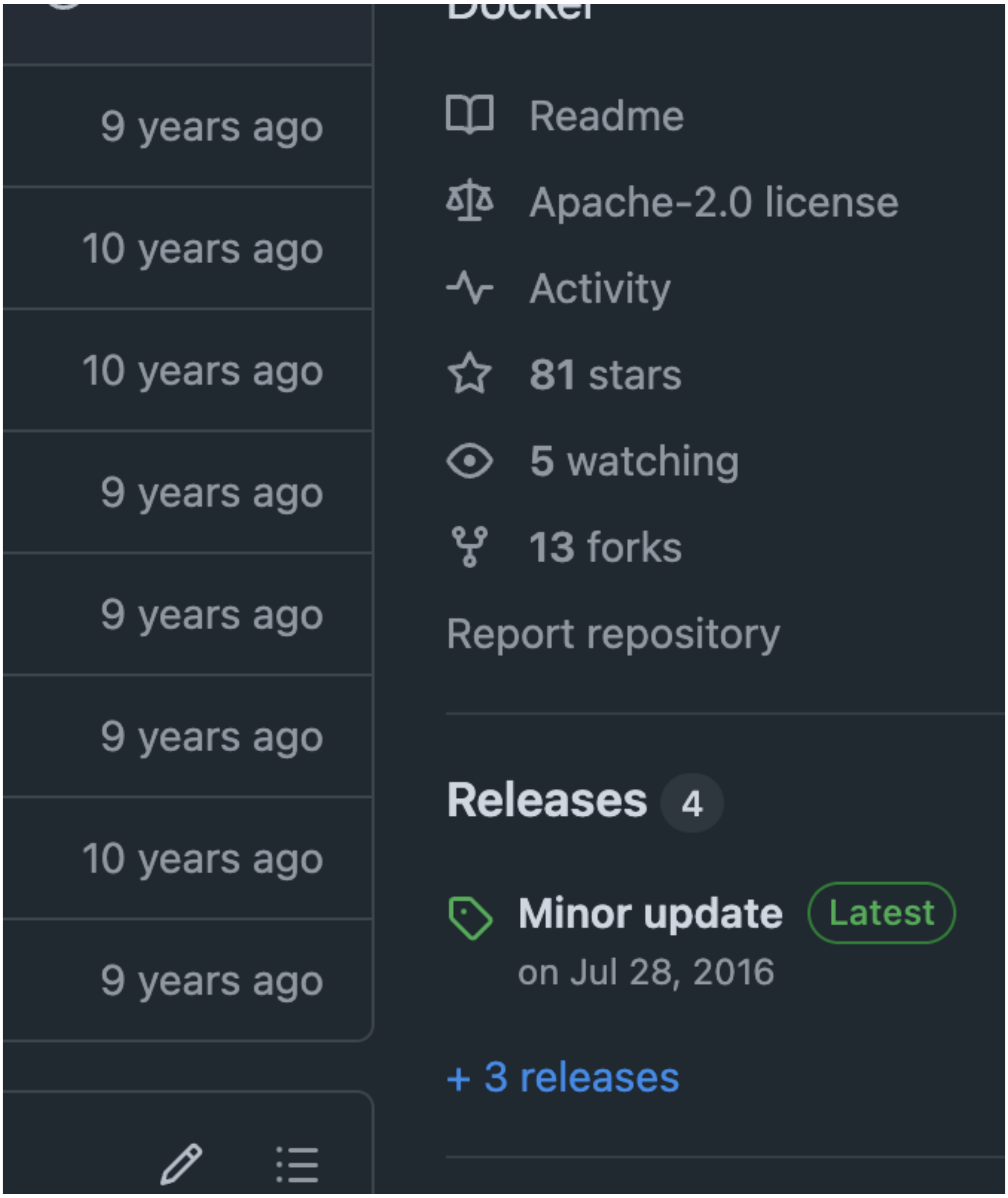
```
postgresql-data:
  external: true
```

The volume must exist with the exact name as described before the script runs as `Docker` will not create `external` volumes. You can create `Docker` volumes with the following command:

```
sudo docker volume create -d local -o type=block -o device=/or-data -o
o=bind or-data
```

With the `-d` flag, you can specify the driver that `Docker` uses for the volume. The default driver is `local`, which I have used for this approach. While there are some AWS `EBS` volume drivers available online, I found out that they are either no longer maintained or rarely updated.


This repository was archived by the owner on May 3, 2018. It is now read-only.


9 years ago

10 years ago

10 years ago

9 years ago

9 years ago

9 years ago

10 years ago

9 years ago

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on Jul 28, 2016

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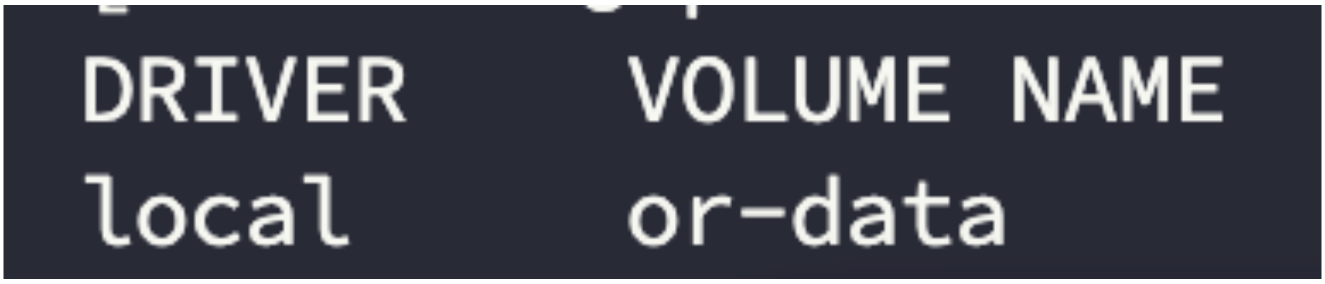
The `o` flag allows you to configure various settings for the drive. I have configured the following settings:

- `type=block`: This informs Docker that the drive is a `block` device (such as a hard disk).
- `device=/or-data`: This tells Docker that the volume directory will be set to `/or-data`. The location of the `EBS` volume.
- `o=bind`: This option is crucial! It ensures that the data for this volume is mapped to the `device` location. Without this option, the folder will remain empty, and the data will not be available on the device.

Lastly, the name of the volume will be set to `or-data`. This name must be used within the `Docker Compose` file so Docker can recognize the volume.

After succesful creating the `Docker` volume you can see them in the `volume` list with the following command.

```
sudo docker volume list.
```



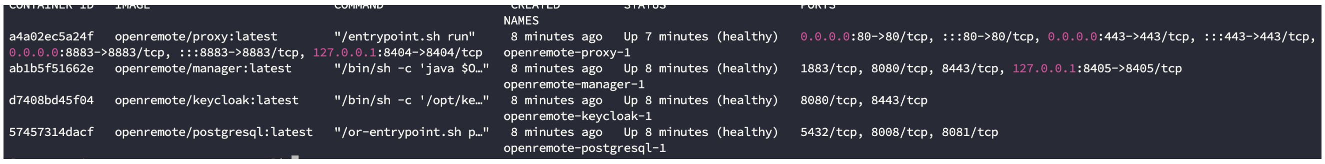
```
DRIVER    VOLUME NAME
local     or-data
```

The `Docker Compose` file should now look like this.

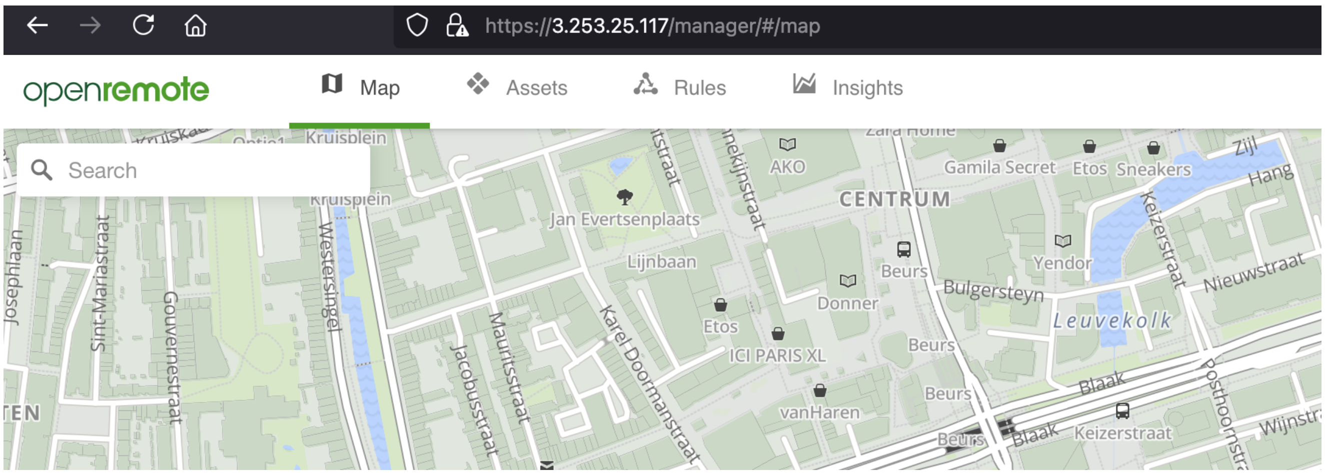
```
# OpenRemote v3
#
# Profile that runs the stack by default on https://localhost using a
self-signed SSL certificate,
# but optionally on https://$OR_HOSTNAME with an auto generated SSL
certificate from Letsencrypt.
#
# It is configured to use the AWS logging driver.
#
volumes:
  proxy-data:
  manager-data:
  postgresql-data:
  or-data:
   external: true

services:
  proxy:
    image: openremote/proxy:${PROXY_VERSION:-latest}
    restart: always
    depends_on:
      manager:
        condition: service_healthy
    ports:
      - 80:80 # Needed for SSL generation using letsencrypt
      - ${OR_SSL_PORT:-443}:443
      - 8883:8883
      - 127.0.0.1:8404:8404 # Localhost metrics access
    volumes:
      - or-data:/deployment
    environment:
      LE_EMAIL: ${OR_EMAIL_ADMIN:-}
      DOMAINNAME: ${OR_HOSTNAME:-localhost}
      DOMAINNAMES: ${OR_ADDITIONAL_HOSTNAMES:-}
      # HAPROXY_DATA_PATH: ${HAPROXY_DATA_PATH:-proxy-data}
      # USE A CUSTOM PROXY CONFIG - COPY FROM https://
raw.githubusercontent.com/openremote/proxy/main/haproxy.cfg
      # HAPROXY_CONFIG: '/data/proxy/haproxy.cfg'

  postgresql:
    restart: always
    image: openremote/postgresql:${POSTGRESQL_VERSION:-latest}
    shm_size: 128mb
    volumes:
      - or-data:/var/lib/postgresql/data/
      - or-data:/storage
    environment:
     PGDATA: /var/lib/postgresql/data/postgres

  keycloak:
    restart: always
    image: openremote/keycloak:${KEYCLOAK_VERSION:-latest}
    depends_on:
      postgresql:
        condition: service_healthy
    volumes:
      - or-data:/deployment
    environment:
      KEYCLOAK_ADMIN_PASSWORD: ${OR_ADMIN_PASSWORD:-secret}
      KC_HOSTNAME: ${OR_HOSTNAME:-localhost}
      KC_HOSTNAME_PORT: ${OR_SSL_PORT:--1}


  manager:
  # privileged: true
    restart: always
    image: openremote/manager:${MANAGER_VERSION:-latest}
    depends_on:
      keycloak:
        condition: service_healthy
    ports:
      - 127.0.0.1:8405:8405 # Localhost metrics access
    environment:
      OR_SETUP_TYPE:
      OR_ADMIN_PASSWORD:
      OR_SETUP_RUN_ON_RESTART:
      OR_EMAIL_HOST:
      OR_EMAIL_USER:
      OR_EMAIL_PASSWORD:
      OR_EMAIL_X_HEADERS:
      OR_EMAIL_FROM:
      OR_EMAIL_ADMIN:
      OR_METRICS_ENABLED: ${OR_METRICS_ENABLED:-true}
      OR_HOSTNAME: ${OR_HOSTNAME:-localhost}
      OR_ADDITIONAL_HOSTNAMES:
      OR_SSL_PORT: ${OR_SSL_PORT:--1}
```

```
        OR_DEV_MODE: ${OR_DEV_MODE:-false}
        # The following variables will configure the demo
        OR_FORECAST_SOLAR_API_KEY:
        OR_OPEN_WEATHER_API_APP_ID:
        OR_SETUP_IMPORT_DEMO_AGENT_KNX:
        OR_SETUP_IMPORT_DEMO_AGENT_VELBUS:
      volumes:
        - or-data:/storage
```

In this situation, there is a single `named` volume created using the `Docker CLI`. The exact name is attached to the `Docker Compose` file, and the value `external: true` ensures that this volume is not automatically created. instead, the existing one will be used. With this setup, the `Docker containers` are spinning up and OpenRemote is available on the `Public IP`

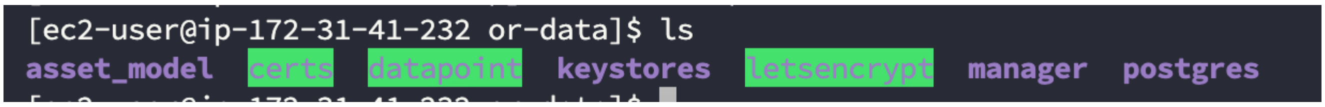


```
CONTAINER ID   IMAGE                          COMMAND                  CREATED         STATUS                   PORTS
                                                                      NAMES
a4a02ec5a24f   openremote/proxy:latest        "/entrypoint.sh run"     8 minutes ago   Up 7 minutes (healthy)   0.0.0.0:80->80/tcp, :::80->80/tcp, 0.0.0.0:443->443/tcp, :::443->443/tcp,
0.0.0.0:8883->8883/tcp, :::8883->8883/tcp, 127.0.0.1:8404->8404/tcp   openremote-proxy-1
ab1b5f51662e   openremote/manager:latest      "/bin/sh -c 'java $0…"   8 minutes ago   Up 8 minutes (healthy)   1883/tcp, 8080/tcp, 8443/tcp, 127.0.0.1:8405->8405/tcp
                                                                      openremote-manager-1
d7408bd45f04   openremote/keycloak:latest     "/bin/sh -c '/opt/ke…"   8 minutes ago   Up 8 minutes (healthy)   8080/tcp, 8443/tcp
                                                                      openremote-keycloak-1
57457314dacf   openremote/postgresql:latest   "/or-entrypoint.sh p…"   8 minutes ago   Up 8 minutes (healthy)   5432/tcp, 8008/tcp, 8081/tcp
                                                                      openremote-postgresql-1
```



3.4. Approach 3 (Named volumes)

The second approach is working, but to improve this setup further, I made some additional changes. Currently, all the data is stored in a single `volume/directory` without subfolders, leading to a large mess.



```
[ec2-user@ip-172-31-41-232 or-data]$ ls
asset_model  certs  datapoint  keystores  letsencrypt  manager  postgres
```

To solve this issue, I created multiple `named` volumes using the `Docker CLI` command and pointed them to subdirectories within the main directory. I also assigned them the same names currently used in the `Docker Compose` file. This ensures that no separate volume needs to be added and we're only using the existing ones.

```
sudo docker volume create -d local -o type=block -o device=/or-data/
proxy -o o=bind proxy-data
sudo docker volume create -d local -o type=block -o device=/or-data/
manager -o o=bind manager-data
```

```
sudo docker volume create -d local -o type=block -o device=/or-data/
postgres -o o=bind postgresql-data
```

The end result looks like this:

```
# OpenRemote v3
#
# Profile that runs the stack by default on https://localhost using a
self-signed SSL certificate,
# but optionally on https://$OR_HOSTNAME with an auto generated SSL
certificate from Letsencrypt.
#
# It is configured to use the AWS logging driver.
#
volumes:
  proxy-data:
   external: ${OR_EXTERNAL_VOLUME:-false}
  manager-data:
   external: ${OR_EXTERNAL_VOLUME:-false}
  postgresql-data:
   external: ${OR_EXTERNAL_VOLUME:-false}

services:
  proxy:
    image: openremote/proxy:${PROXY_VERSION:-latest}
    restart: always
    depends_on:
      manager:
        condition: service_healthy
    ports:
      - 80:80 # Needed for SSL generation using letsencrypt
      - ${OR_SSL_PORT:-443}:443
      - 8883:8883
      - 127.0.0.1:8404:8404 # Localhost metrics access
    volumes:
      - proxy-data:/deployment
    environment:
      LE_EMAIL: ${OR_EMAIL_ADMIN:-}
      DOMAINNAME: ${OR_HOSTNAME:-localhost}
      DOMAINNAMES: ${OR_ADDITIONAL_HOSTNAMES:-}
      # HAPROXY_DATA_PATH: ${HAPROXY_DATA_PATH:-proxy-data}
      # USE A CUSTOM PROXY CONFIG - COPY FROM https://
raw.githubusercontent.com/openremote/proxy/main/haproxy.cfg
      # HAPROXY_CONFIG: '/data/proxy/haproxy.cfg'

  postgresql:
    restart: always
    image: openremote/postgresql:${POSTGRESQL_VERSION:-latest}
    shm_size: 128mb
    volumes:
      - postgresql-data:/var/lib/postgresql/data/
      - manager-data:/storage

  keycloak:
    restart: always
    image: openremote/keycloak:${KEYCLOAK_VERSION:-latest}
    depends_on:
      postgresql:
        condition: service_healthy
    volumes:
      - ./deployment:/deployment
    environment:
      KEYCLOAK_ADMIN_PASSWORD: ${OR_ADMIN_PASSWORD:-secret}
      KC_HOSTNAME: ${OR_HOSTNAME:-localhost}
      KC_HOSTNAME_PORT: ${OR_SSL_PORT:--1}


  manager:
  # privileged: true
    restart: always
    image: openremote/manager:${MANAGER_VERSION:-latest}
    depends_on:
      keycloak:
        condition: service_healthy
    ports:
      - 127.0.0.1:8405:8405 # Localhost metrics access
    environment:
      OR_SETUP_TYPE:
      OR_ADMIN_PASSWORD:
      OR_SETUP_RUN_ON_RESTART:
      OR_EMAIL_HOST:
      OR_EMAIL_USER:
      OR_EMAIL_PASSWORD:
      OR_EMAIL_X_HEADERS:
      OR_EMAIL_FROM:
      OR_EMAIL_ADMIN:
      OR_METRICS_ENABLED: ${OR_METRICS_ENABLED:-true}
      OR_HOSTNAME: ${OR_HOSTNAME:-localhost}
      OR_ADDITIONAL_HOSTNAMES:
      OR_SSL_PORT: ${OR_SSL_PORT:--1}
      OR_DEV_MODE: ${OR_DEV_MODE:-false}
      # The following variables will configure the demo
      OR_FORECAST_SOLAR_API_KEY:
      OR_OPEN_WEATHER_API_APP_ID:
      OR_SETUP_IMPORT_DEMO_AGENT_KNX:
      OR_SETUP_IMPORT_DEMO_AGENT_VELBUS:
    volumes:
     - manager-data:/storage
```

The files are now structered in different subfolders

```
[ec2-user@ip-172-31-41-232 or-data]$ ls
manager   postgres   proxy
```

Lastly, I added an `environment` variable to make this approach more modular and easily configurable. The environment variable `${OR_EXTERNAL_VOLUME:-false}` is included in the volume block at the top of the file. If no value is provided, the default value of `false` is applied, meaning the data will be stored on the same `root` device. If the value is set to `true`, `Docker` will search for the external volume in the list and use that one if it exists.

The user can change the `environment` variable be adding it to the `Docker Compose` start command like so:

```
OR_HOSTNAME=<PUBLIC IP> OR_EXTERNAL_VOLUME=true docker-compose -p
openremote up -d
```

3.5. Approach 4 (Named volumes)

I continued optimizing this approach and after tweaking the `Docker Compose` file a little more, I currently have the following result:

```
# OpenRemote v3
#
# Profile that runs the stack by default on https://localhost using a
self-signed SSL certificate,
# but optionally on https://$OR_HOSTNAME with an auto generated SSL
certificate from Letsencrypt.
#
# It is configured to use the AWS logging driver.
#
volumes:
  proxy-data:
   driver_opts:
    type: block
    device: ${OR_PROXY_PATH:-/var/lib/docker/volumes/openremote_proxy-
data/_data}
    o: bind
  manager-data:
   driver_opts:
    type: block
    device: ${OR_MANAGER_PATH:-/var/lib/docker/volumes/
openremote_manager-data/_data}
    o: bind
  postgresql-data:
   driver_opts:
    type: block
    device: ${OR_POSTGRES_PATH:-/var/lib/docker/volumes/
openremote_postgresql-data/_data}
    o: bind

services:
  proxy:
    image: openremote/proxy:${PROXY_VERSION:-latest}
    restart: always
    depends_on:
      manager:
        condition: service_healthy
    ports:
      - 80:80 # Needed for SSL generation using letsencrypt
      - ${OR_SSL_PORT:-443}:443
      - 8883:8883
      - 127.0.0.1:8404:8404 # Localhost metrics access
    volumes:
      - proxy-data:/deployment
    environment:
      LE_EMAIL: ${OR_EMAIL_ADMIN:-}
      DOMAINNAME: ${OR_HOSTNAME:-localhost}
      DOMAINNAMES: ${OR_ADDITIONAL_HOSTNAMES:-}
      # USE A CUSTOM PROXY CONFIG - COPY FROM https://
raw.githubusercontent.com/openremote/proxy/main/haproxy.cfg
      # HAPROXY_CONFIG: '/data/proxy/haproxy.cfg'

  postgresql:
    restart: always
    image: openremote/postgresql:${POSTGRESQL_VERSION:-latest}
    shm_size: 128mb
    volumes:
      - postgresql-data:/var/lib/postgresql/data
      - manager-data:/storage

  keycloak:
    restart: always
    image: openremote/keycloak:${KEYCLOAK_VERSION:-latest}
    depends_on:
      postgresql:
        condition: service_healthy
    volumes:
      - ./deployment:/deployment
    environment:
      KEYCLOAK_ADMIN_PASSWORD: ${OR_ADMIN_PASSWORD:-secret}
      KC_HOSTNAME: ${OR_HOSTNAME:-localhost}
      KC_HOSTNAME_PORT: ${OR_SSL_PORT:--1}


  manager:
  # privileged: true
    restart: always
    image: openremote/manager:${MANAGER_VERSION:-latest}
    depends_on:
      keycloak:
        condition: service_healthy
    ports:
      - "127.0.0.1:8405:8405" # Localhost metrics access
    environment:
      OR_SETUP_TYPE:
      OR_ADMIN_PASSWORD:
      OR_SETUP_RUN_ON_RESTART:
      OR_EMAIL_HOST:
      OR_EMAIL_USER:
      OR_EMAIL_PASSWORD:
      OR_EMAIL_X_HEADERS:
      OR_EMAIL_FROM:
      OR_EMAIL_ADMIN:
      OR_METRICS_ENABLED: ${OR_METRICS_ENABLED:-true}
      OR_HOSTNAME: ${OR_HOSTNAME:-localhost}
      OR_ADDITIONAL_HOSTNAMES:
      OR_SSL_PORT: ${OR_SSL_PORT:--1}
      OR_DEV_MODE: ${OR_DEV_MODE:-false}

      # The following variables will configure the demo
      OR_FORECAST_SOLAR_API_KEY:
      OR_OPEN_WEATHER_API_APP_ID:
      OR_SETUP_IMPORT_DEMO_AGENT_KNX:
      OR_SETUP_IMPORT_DEMO_AGENT_VELBUS:
    volumes:
      - manager-data:/storage
```

In this setup, the named `volumes` are now automatically created by `Docker` with the options I previously specified in the `CLI` command. I added `environment` variables so that each `container` can have its own location for storing data. This approach also eliminates the need for the `PGDATA` variable. If no location is provided, `Docker` will use the default location on the `root` device itself.

The start command looks like this.

```
OR_HOSTNAME=<PUBLIC IP> OR_PROXY_PATH=/or-data/proxy OR_MANAGER_PATH=/
or-data/manager OR_POSTGRES_PATH=/or-data/postgres docker-compose -p
openremote up -d
```

3.6. Tests

To ensure the implementation is functioning correctly, I have tested it with various test cases.

3.6.1. Setup

The test setup is using the following resources within the `OpenRemote` software:

- `Agents`
    - `HTTP Agent` This agent connects to an API that returns a random number between `0` and `100`.
- `Assets`
    - `Thermostat Asset` This asset is connected to the `HTTP Agent` and polls every `5000` milliseconds to retrieve a new random number and displays this in the `Number` attribute. Additionally, an `AttributeLink` is connected to copy the value from the `Number` attribute to the `temperature` attribute.
- `Dashboard`
    - `Attribute widget` This widget displays the actual value in the `Number` attribute.
    - `Gauge widget` This widget displays the most recent value from the `temperature` attribute (since the last refresh) within a `gauge`.

3.6.2. Test Cases

The following test cases are described and executed:

Test cases	Machine is booting properly	OpenRemote is starting	The data is available	No data is missing	Agents are connected	No errors occured
1. Connect the EBS data volume to a new EC2 instance while the OpenRemote software is active.	✅	✅	✅	✅	✅	✅
2. Connect the EBS data volume to a new EC2 instance while the OpenRemote software is inactive.	✅	⚠️	⚠️	⚠️	⚠️	⚠️
3. Disconnect the EBS data volume from a running EC2 instance with the OpenRemote software active.	✅	✅	✅	✅	✅	✅
4. Disconnect the EBS data volume from a running EC2 instance while the OpenRemote software is inactive.	✅	✅	✅	✅	✅	✅
5. Start OpenRemote with the newly connected and configured EBS data volume with an active TLS (Let's encrypt)	✅	✅	✅	✅	✅	✅

Test cases	Machine is booting properly	OpenRemote is starting	The data is available	No data is missing	Agents are connected	No errors occured
certificate and FQDN (Domain) using Amazon `Route53`.						
6. Restart OpenRemote with the newly connected and configured `EBS` data volume with the newly connected and configured `EBS` data volume with an active TLS (Let's encrypt) certificate and FQDN (Domain) using Amazon `Route53`.	✅	✅	✅	✅	✅	✅
7. Reboot `EC2` machine with the newly connected and configured `EBS` data volume with the newly connected and configured `EBS` data volume with an active TLS (Let's encrypt) certificate and FQDN (Domain) using Amazon `Route53`.	✅	✅	✅	✅	✅	✅
8. Stop `EC2` machine with the newly connected and configured `EBS` data volume	✅	✅	✅	✅	✅	✅

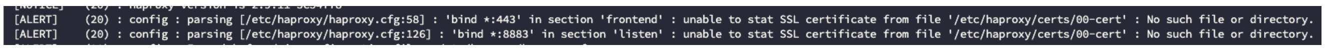
Test cases	Machine is booting properly	OpenRemote is starting	The data is available	No data is missing	Agents are connected	No errors occured
with the newly connected and configured EBS data volume with an active TLS (Let's encrypt) certificate and FQDN (Domain) using Amazon `Route53`.						
9. Start OpenRemote with the newly connected and configured EBS data volume with an active TLS (Let's encrypt) certificate and without an connected FQDN (Domain) using Amazon `Route53`.	✅	✅	✅	✅	✅	✅
10. Restart OpenRemote with the newly connected and configured EBS data volume with an active TLS (Let's encrypt) certificate and without an connected FQDN (Domain) using Amazon `Route53`.	✅	✅	✅	✅	✅	✅
11. Reboot OpenRemote with	✅	✅	✅	✅	✅	✅

Test cases	Machine is booting properly	OpenRemote is starting	The data is available	No data is missing	Agents are connected	No errors occured
the newly connected and configured `EBS` data volume with an active TLS (Let's encrypt) certificate and without an connected FQDN (Domain) using Amazon `Route53`.						
12. Stop OpenRemote with the newly connected and configured `EBS` data volume with an active TLS (Let's encrypt) certificate and without an connected FQDN (Domain) using Amazon `Route53`.	✅	✅	✅	✅	✅	✅
13. Start OpenRemote with the newly connected and configured `EBS` data volume with the newly connected and configured `EBS` data volume with an active TLS (Let's encrypt) certificate and using the `Public IP`.	✅	✅	✅	✅	✅	✅

Test cases	Machine is booting properly	OpenRemote is starting	The data is available	No data is missing	Agents are connected	No errors occured
14. Restart OpenRemote with the newly connected and configured EBS data volume with the newly connected and configured EBS data volume with an active TLS (Let's encrypt) certificate and using the `Public IP`.	✅	⚠️	⚠️	⚠️	⚠️	⚠️
15. Reboot EC2 machine with the newly connected and configured EBS data volume with the newly connected and configured EBS data volume with an active TLS (Let's encrypt) certificate and using the `Public IP`.	✅	⚠️	⚠️	⚠️	⚠️	⚠️
16. Stop EC2 machine with the newly connected and configured EBS data volume with the newly connected and configured EBS data volume with an active TLS (Let's encrypt) certificate and	✅	⚠️	⚠️	⚠️	⚠️	⚠️

Test cases	Machine is booting properly	OpenRemote is starting	The data is available	No data is missing	Agents are connected	No errors occured
using the `Public IP`.						

The test results indicate that when using a `Public IP`, the OpenRemote software occasionally fails to start properly. When reviewing the logs, it turns out that the `proxy` container sometimes encounters issues while setting the self-signed certificate.



```
[ALERT]    (20) : config : parsing [/etc/haproxy/haproxy.cfg:58] : 'bind *:443' in section 'frontend' : unable to stat SSL certificate from file '/etc/haproxy/certs/00-cert' : No such file or directory.
[ALERT]    (20) : config : parsing [/etc/haproxy/haproxy.cfg:126] : 'bind *:8883' in section 'listen' : unable to stat SSL certificate from file '/etc/haproxy/certs/00-cert' : No such file or directory.
```

To solve this problem, you need to manually start and stop the `Docker` containers using the following commands:

```
docker-compose down
```

```
docker-compose up
```

4. Advise & Summary

In this section, I will outline the final results of this research and the next steps as discussed.

4.1. Advise

After exploring the possibilities of decoupling the IoT data and storing it on a separate `EBS` data volume, I conclude that several approaches are effective. Based on the prototype, I recommend using the first approach, as it is the simplest option and requires minimal changes to the `Docker Compose` file.

4.2. Feedback from Team Members

Based on the feedback from various team members, I've received several keypoints for further development.

- Investigate the possibilities to mount the seperate `EBS` data volume to the existing `Docker` directory on the root volume instead of creating an new directory.
- Re-create the prototype in the existing CI/CD pipeline (`provision host`) including features such as automatic `create/mount` volume, `attach/detach` volume script, `CloudWatch` metrics and automate the `snapshot` creation process.
- Investigate the possibilities for `blue/green deployments` and multi-attach `EBS` data volumes.

4.3. Next Steps

In the coming weeks, I will integrate and test my prototype within the `provision host` CI/CD workflow.

5. Source

The following sources are used for this research:

- Amazon EBS volumes - Amazon EBS. (n.d.). https://docs.aws.amazon.com/ebs/latest/userguide/ebs-volumes.html
- Amazon EBS volume types - Amazon EBS. (n.d.). https://docs.aws.amazon.com/ebs/latest/userguide/ebs-volume-types.html
- Amazon EBS volume lifecycle - Amazon EBS. (n.d.). https://docs.aws.amazon.com/ebs/latest/userguide/ebs-volume-lifecycle.html
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- Several Stackoverflow posts for debugging problems while creating prototypes.