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1. Assignment Overview

Motivation
After the implementation of the website on AWS cloud, Shops R' Us will have more options in fine tuning the website security. In addition, Shops R' Us do not need to purchase on-premise hardware since it will be handled by AWS. Lastly, when there is a significant increase in the website traffic, it is easier for Shop R' Us to scale up on cloud in comparison to when they host it on-premise. They will not get caught in the scenario for long lead time when ordering the hardware.

Objectives
Shops R'Us would like to develop and deploy an online shopping website which is able to facilitate different customer events such placing a purchase, browsing products, create profiles and make payment. The website developed in this assignment is able to support placing a purchase only (which is used an illustration since this is a cloud architecting course, but in real life the website should be able to handle multiple events).

Scopes
The scope of this project includes :
- Database of the website will be hosted in MySQL format securely.
- All administrators will be able to access to AWS console securely.
- Other web users will be able to access the website anonymously.
- Administrators will also be able to use bastion host to securely access instances (especially private instances) via SSH.
- By using the Load Balancer which distributes incoming traffic to two Availability Zones.
- Auto-Scaling Group is used to scale-in or scale-out of web and app tier EC2 according to the traffic.
- Cloud Trail is used hence administrator is able to store and monitor activities performed by different users (AWS CloudTrail, 2023).

Assumptions
- Only one EC2 is created for the web and app server, by assuming that Shop R' Us is a small medium enterprise when one EC2 (t2 micro size) is able to handle the website.
- 256 IP addresses per subnet are assigned for each public/private subnet, by assuming that 251 addresses (where the other five addresses are reserved for AWS) are sufficient for Shop R' Us.

2. Architecture Design

Identify AWS Services

Requirement	AWS Service / Solution	Justification
Database (MySQL format)	RDS	To create relational databases as the storage (AWS RDS, 2023)
Network	VPC	To host all public subnets, private subnets and all associated instances (AWS VPC, 2023)
Activities Monitoring	Cloud Trail	To monitor activities performed by different users and store activities as logs (AWS CloudTrail, 2023)
Traffic Distribution	Elastic Load Balancer	To distribute traffics going into website into EC2 in different AZs (AWS ELB, 2023)
Server Capacities Adjustment	Auto-Scaling	To perform scaling-in or scaling-out of EC2 instances of web and application server according to traffic demand (AWS Auto-Scaling, 2023)
Compute	EC2	To cater computing resources to the web and application server (AWS EC2, 2023)
Software Development	Cloud9	To provide development environment which can be run and deployed on EC2 (AWS Cloud9, 2023)
Users Creation	IAM	To create roles, groups, users. Users can be assigned into groups (AWS IAM, 2023)

Architecture Diagram

Architecture Diagram is provided in Appendix

Network

VPC	Region	Purpose	No of Subnets	No of AZs	CIDR Range
myVPC	us-east-1 (N.Virginia)	To host all public subnets, private subnets and all associated instances (AWS VPC, 2023)	4 (with 2 subnets per AZ)	2	10.0.0.0/16

- NAT gateway is utilised to connect private subnet to internet
- Two AZs are created hence the website is highly available. Therefore, when 1 AZ is failed, there is a backup on the other AZ.

Production Subnet Details

Subnet Name	VPC	Subnet Type (Public/Private)	AZ	Subnet Address
Public Subnet 1	1	Public	us-east-1a	10.0.0.0/24
Private Subnet 1	1	Private	us-east-1a	10.0.2.0/24
Public Subnet 2	1	Public	us-east-1b	10.0.1.0/24
Private Subnet 2	1	Private	us-east-1b	10.0.3.0/24

Instance Details

Tier	**Tag**	**OS**	**Type**	**Size**	**Justification**	**# of instances**
web-app	key: **Name** value: **ShopAPP**	Amazon Linux	EC2	t2.micro (1vCPU,1GiB RAM)	to cater computing and storage for web and app tier (AWS EC2, 2023)	Two for web-app (one instance per AZ) One instance for bastion host in the first AZ
database	key: **Name** value: **DBTier**	N/A	RDS	200GiB	to cater relational database storage for the website (AWS RDS, 2023)	two (one instance per AZ)

The RDS created in the private subnet 2 acts as the secondary (backup) of the RDS created in Private Subnet 1

Application Load Balancer:

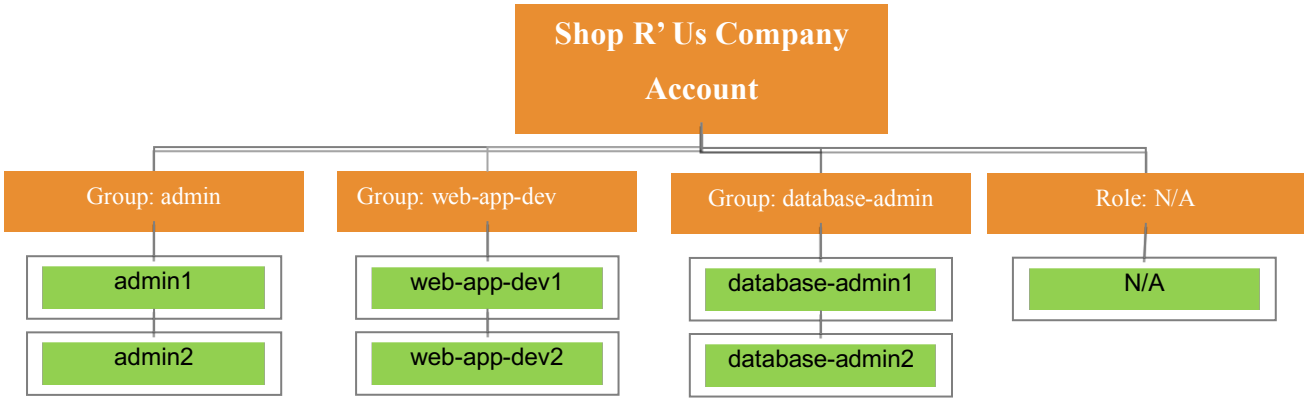
Tier	**Type**	**Group Name**	**Tag**	**VPC**	**Subnets**	**Security Group**
web-app	Application Load Balancer	web-app-lb	key: **name** value: **web-app-elb**	myVPC	Public Subnet 1 & Public Subnet 2	web-app-lb-sg

Auto Scaling Group

Tier	Launch Config	Group Name	Group Size (min,max)	VPC	Subnets	ELB
web-app	after the website code is deployed on Cloud9, the EC2 created by Cloud9 is used to create AMI and afterwards used as Launch Config	web-app-asg	Desired capacity: 2 Min capacity: 1 Max capacity: 2	myVPC	Public Subnet 1 and Public Subnet 2	web-app-elb

The EC2 will scale out from 1 instance to 2 instances when the traffic is high.

3. Security Design

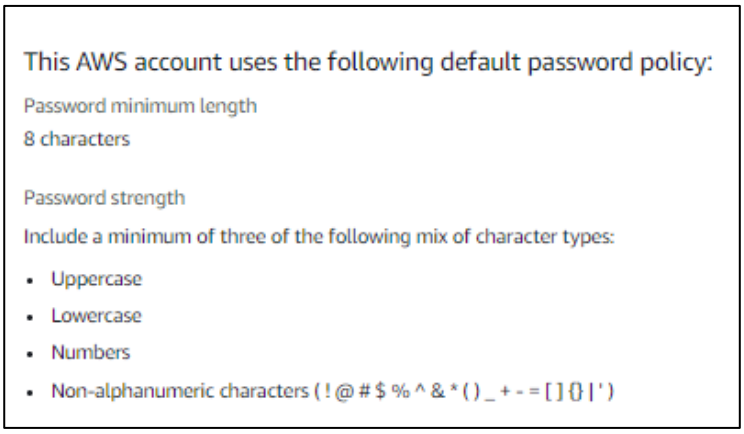


User Authentication

Group/Role	Group/Role name	Permissions
Group	admin	Admin is able to create, stop, start all instances. Admin is able to create new roles, user groups and users using IAM.
Group	web-app-dev	Web-app-dev user group is able to start, stop and view ELB, Auto-Scaling, EC2, Bastion Hosts. This group may only read RDS.
Group	database-admin	Database-admin is able to start, stop and view RDS instance. This group has only read access to ELB, Auto-Scaling, EC2, Bastion Hosts.

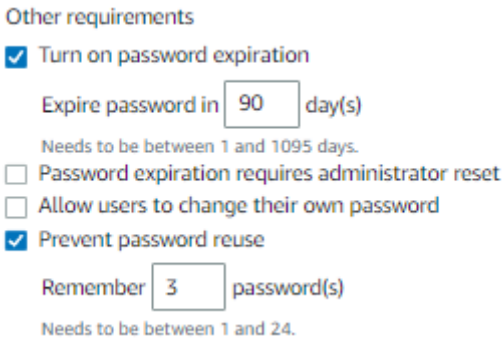
In addition, the following configurations will apply to all users:

- Passwords for all users by default follows the policy below, which have been applied when the users are created.



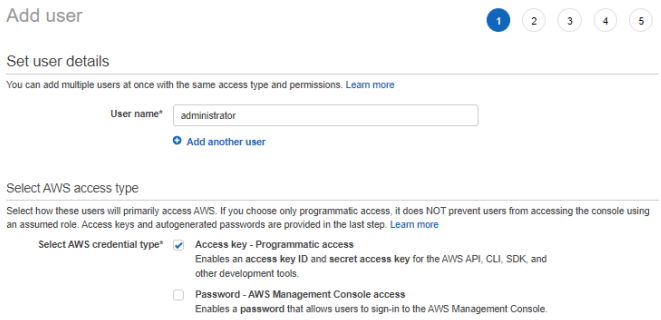
(AWS Default, 2023)

- Passwords must be changed every 3 months and users are unable to use their previous 3 passwords. For each user, go to IAM and clicked on ‘account setting’ and choose ‘edit password policy’ :



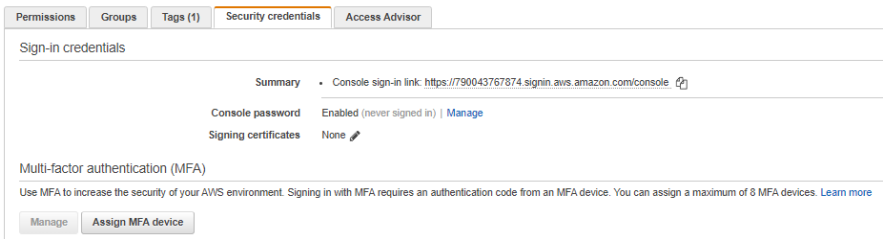
(AWS Password, 2023)

- All the user groups mentioned above will have programmatic access, and this feature is enabled when each user is created as shown below:



(AWS Programmatic, 2023)

- Multi-Factor Authentication will be used for all users where they are required an authentication code on their registered MFA device. This can be achieved by clicking on the created users and click on the ‘Security Credential’ tab, which is able to assign the MFA device, as shown below:



(AWS MFA, 2023)

Security Groups

Security Group (SG)	SG Name	Rule	Source
Bastion Security Group	bastion-sg	**Inbound Rule:** Type: SSH Protocol: TCP Port Range: 22 **Outbound Rule:** Type: All Traffic Protocol: All Port Range: All	**Inbound Rule:** Source: 0.0.0.0/0 **Outbound Rule:** Source: 0.0.0.0/0
Load Balancer Security Group	web-app-lb-sg	**Inbound Rule:** Type: HTTP Protocol: TCP Port Range: 80 **Inbound Rule:** Type: HTTPS Protocol: TCP Port Range: 443 **Outbound Rule:** Type: All Traffic Protocol: All Port Range: All	**Inbound Rule:** Source: 0.0.0.0/0 **Inbound Rule:** Source: 0.0.0.0/0 **Outbound Rule:** Source: 0.0.0.0/0
Web Application Security Group	web-app-server-sg	**Inbound Rule:** Type: SSH Protocol: TCP Port Range: 22 **Inbound Rule:** Type: HTTP Protocol: TCP Port Range: 80 **Outbound Rule:** Type: All Traffic Protocol: All Port Range: All	**Inbound Rule:** Source: bastion-sg (security group of bastion host) **Inbound Rule:** Source: web-app-lb-sg (security group of load balancer) **Outbound Rule:** Type: All Traffic Source: 0.0.0.0/0
Database Security Group	database-sg	**Inbound Rule:** Type: all TCP Protocol: TCP Port Range: 0-65535 *(by selecting all TCP is to allow connection of RDS to MySQL bench)*	**Inbound Rule:** Source: 0.0.0.0/0

		Inbound Rule (alternative): Type: MYSQL/Aurora Protocol: TCP Port Range: 3306 *(This is the alternative more secure inbound rule to allow access from web-app tier only. However, by choosing this configuration, RDS is unable to connect to MySQL bench)* **Outbound Rule:** Type: All Traffic Protocol: All Port Range: All	**Inbound Rule (alternative):** Source: web-app-server-sg (security group Web-App-Tier) **Outbound Rule:** Type: All Traffic Source: 0.0.0.0/0

Other Security Options

Other Security Options	Justifications
KMS Key	Encryption SDK key will be used to encrypt traffics flowing across AWS (AWS KMS, 2023)
SSL/TLS	An encrypted connection of network will be established in web browser when this feature is used (AWS SSL, 2023)

Cost Considerations

In estimating the costs, Singapore is chosen as the region assuming that Shop R' Us headquarter is in Singapore.

The following assumptions are made when calculating the costs:

VPC

- 4 subnets associations
- 22 working days per month
- 1 NAT Gateway
- Data processed per NAT Gateway: 20 GB per month
- Data transferred from internet: 20 GB (it is free)
- Outbound transfer: 20 GB

Cloud Trail

Maximum 1000 write management of events per day, hence 30000 per month

ELB

500 new connection per second, where maximum of 500 customers visit the website per second

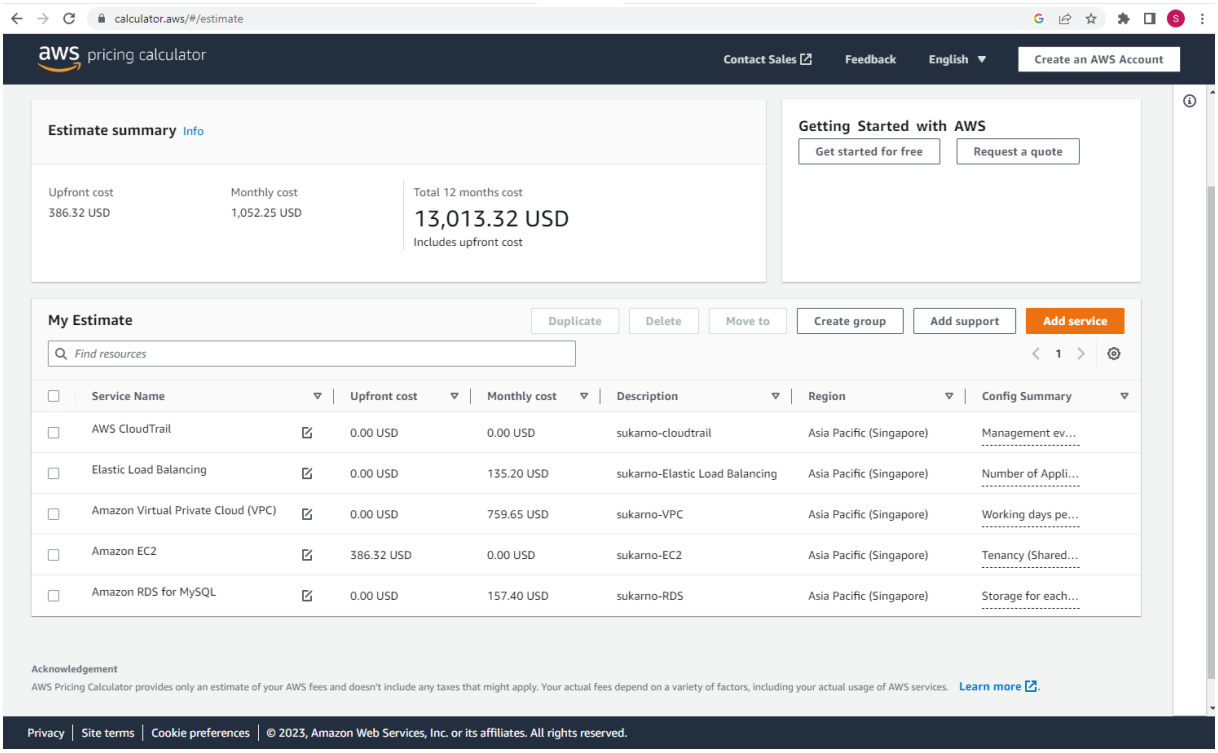
3 EC2 instances (2 EC2 for web-app-tier and 1 EC2 for bastion host)

- Shared instances
- Linux operating system
- Workloads: constant usage
- t2.micro family
- EC2 Saving Instance Plans, reserve term 3 years and pay all upfront

RDS for mySQL (2 instances)

- db.m1.small (1 vCPU and 1.7 GiB memory)
- General Purpose SSD (gp2)
- 200 GB storage

Summary of Price is as follow:



(AWS Pricing, 2023)

Shop R' Us can expect to pay USD 1052.25/month or USD 13,013.32/year.

4. Design Limitations

The login details of RDS is directly provided inside codes of the website. This is not the best practice since when the security of the website is compromised, the login details can be leaked easily. The login details include:

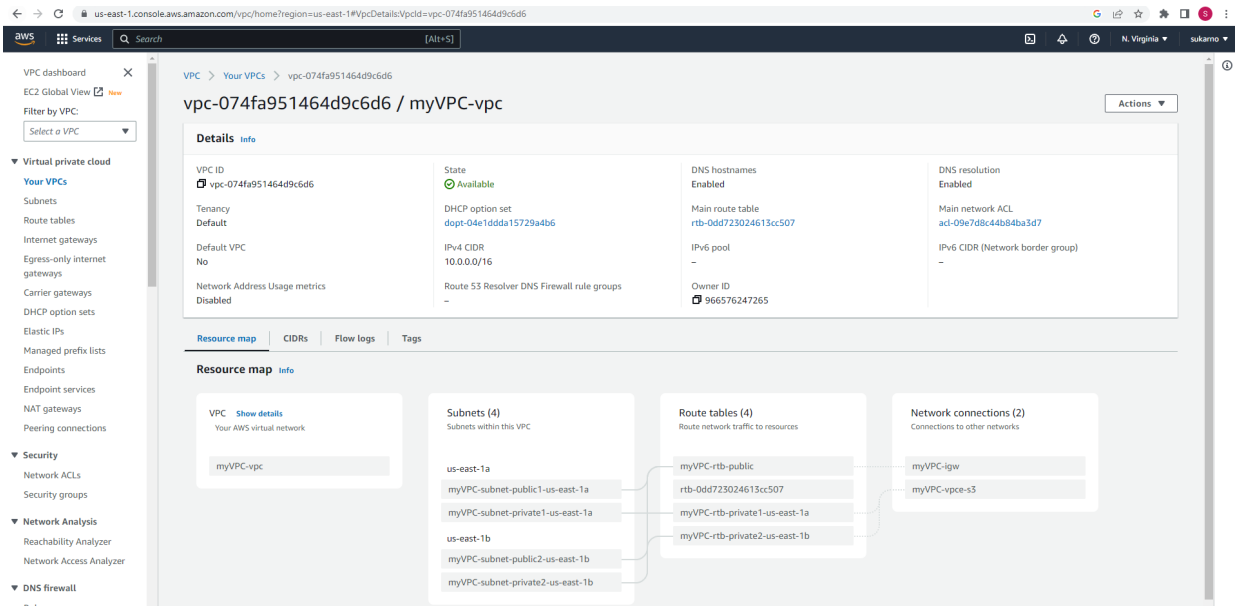
- Endpoint
- Username
- Password
- Database name

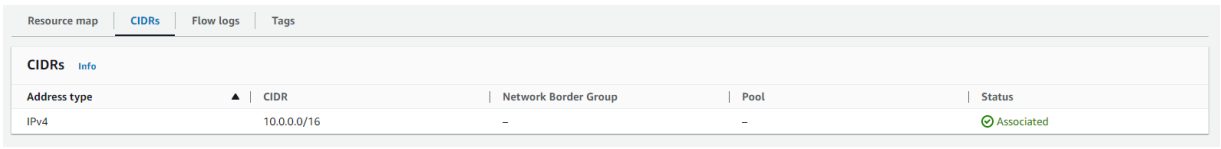
This can be improved by storing these parameters in AWS System Manager Parameter Store. Hence the website will retrieve these login details every time the website is loaded.

5. Implementation

Step 1: Create a new VPC

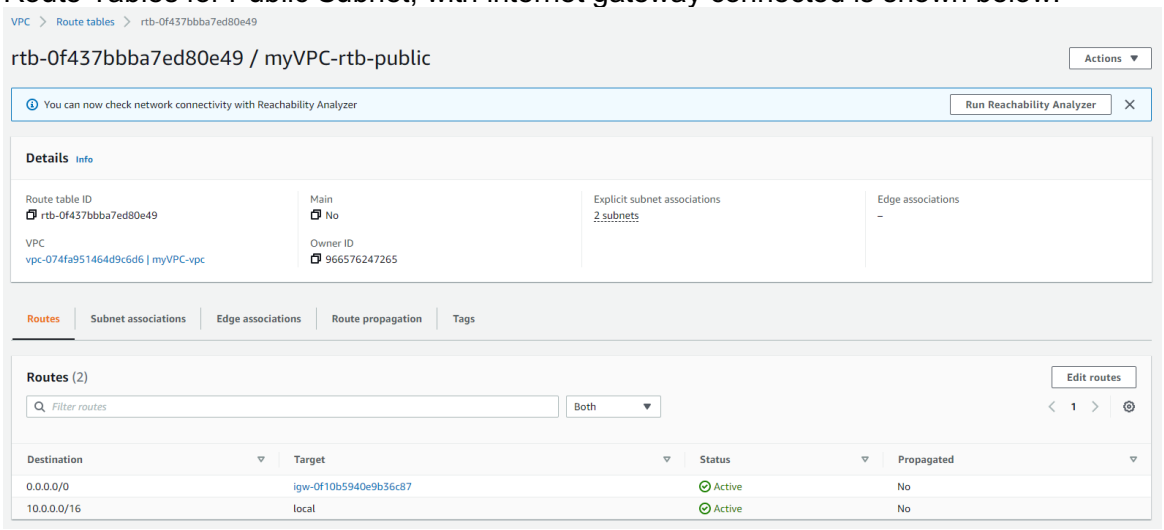
A new VPC with the name “myVPC” is created, as follow:

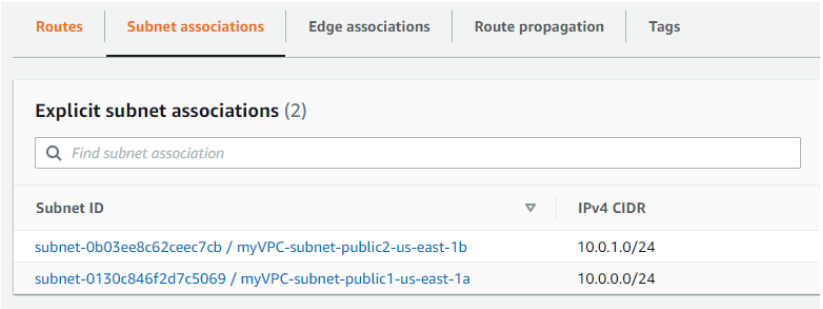




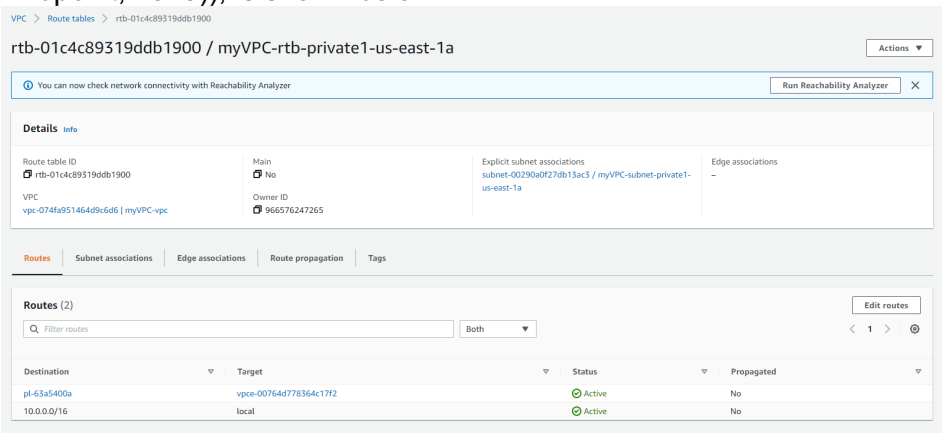
The details of production subnets have been provided in Section 2.

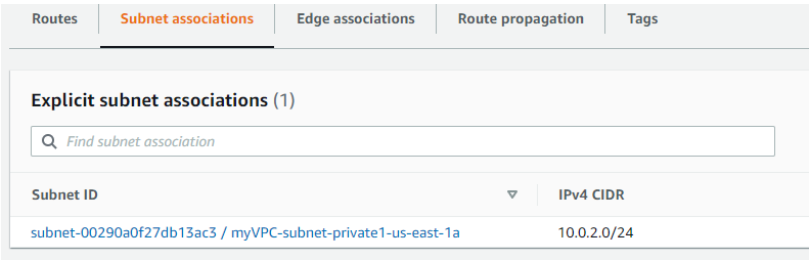
Route Tables for Public Subnet, with internet gateway connected is shown below:



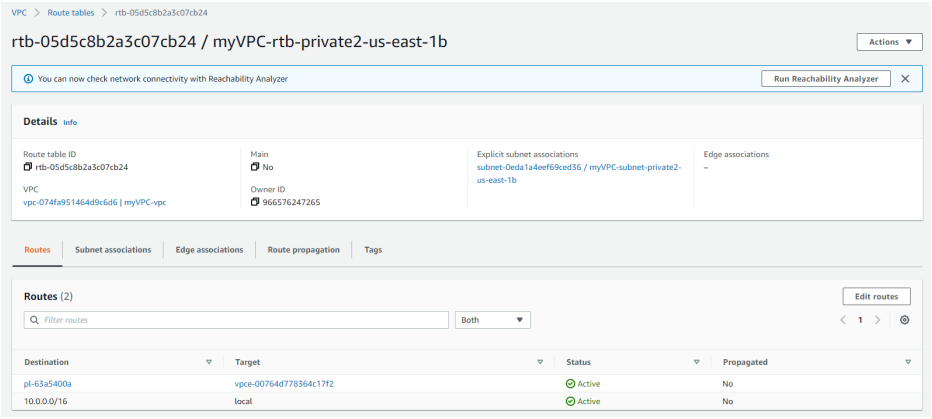


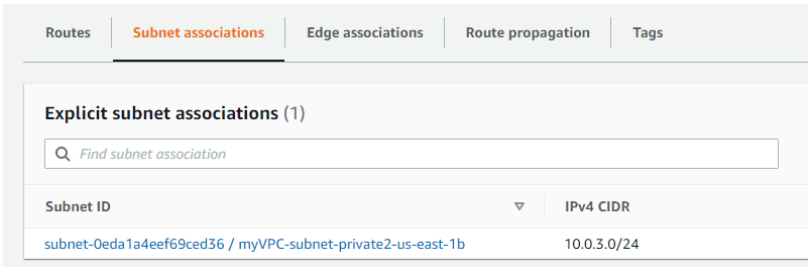
Route table for Private Subnet 1 (where vpce is the VPC endpoint which is created as the alternative connection to private subnet without requiring internet gateway and NAT (AWS Endpoint, 2023)), is shown below:



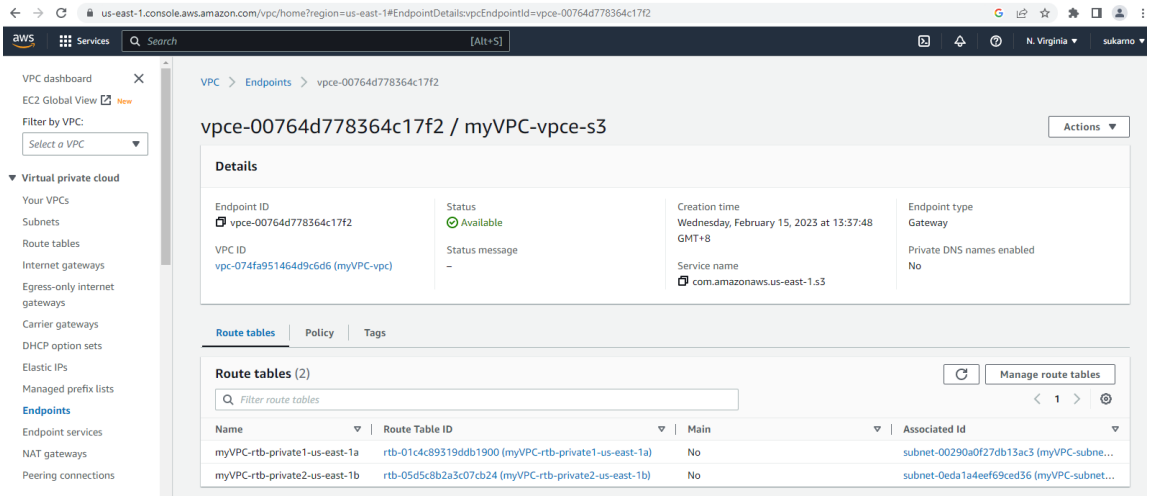


Route table for Private Subnet 2 is shown below:



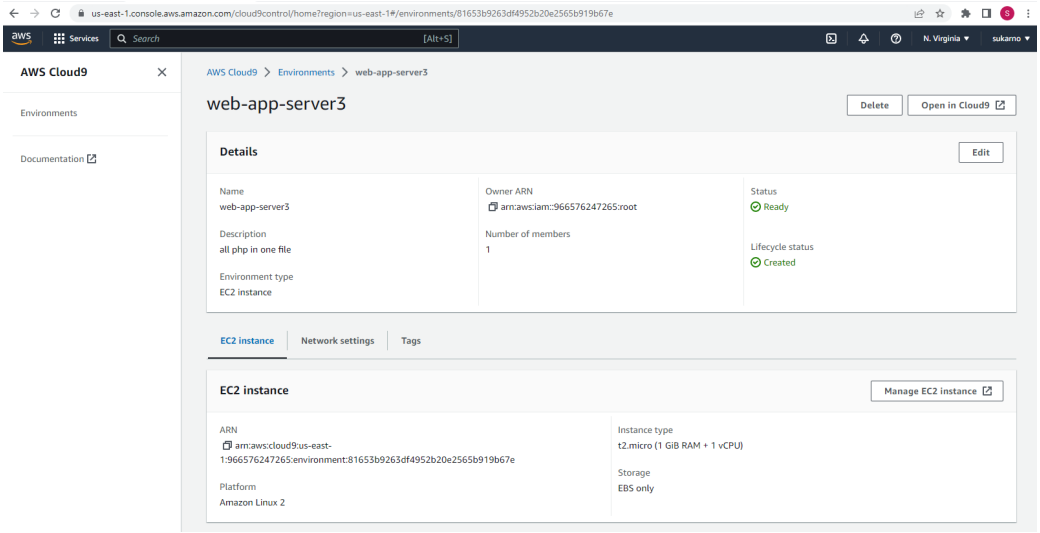


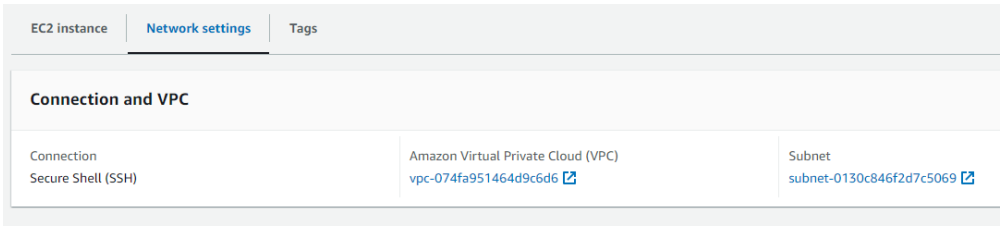
Endpoint



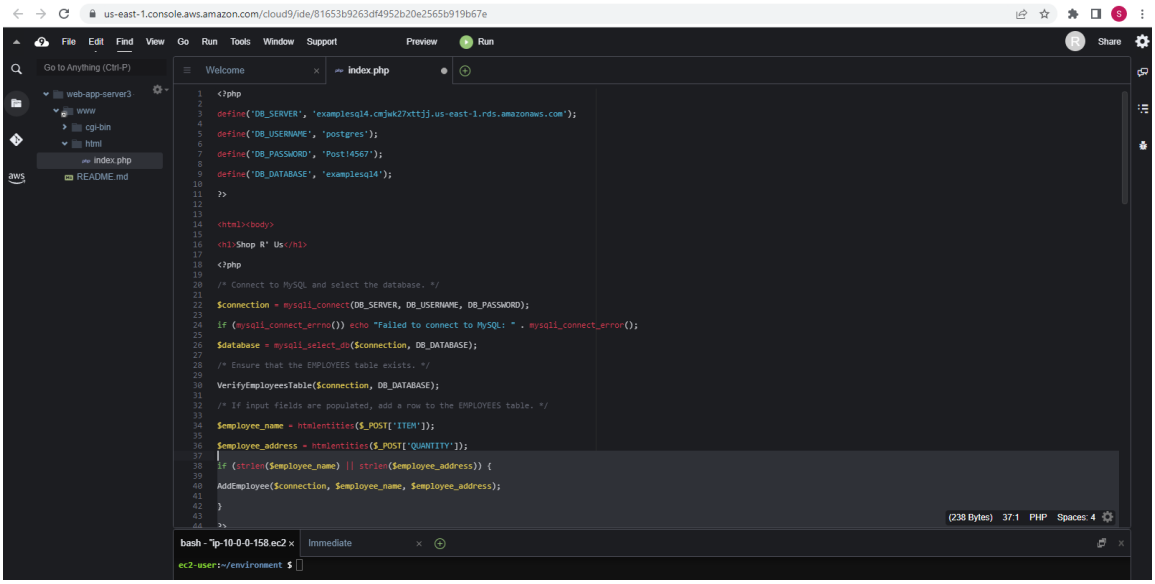
Step 2: Developing Shop R' Us website using Cloud9

A simple website was cloned from github, which is developed by Nguyen (2018). The code was imported using Cloud9 and afterwards modified to suit the needs of Shop R' Us. The configuration of the Cloud9 environment is as follow:

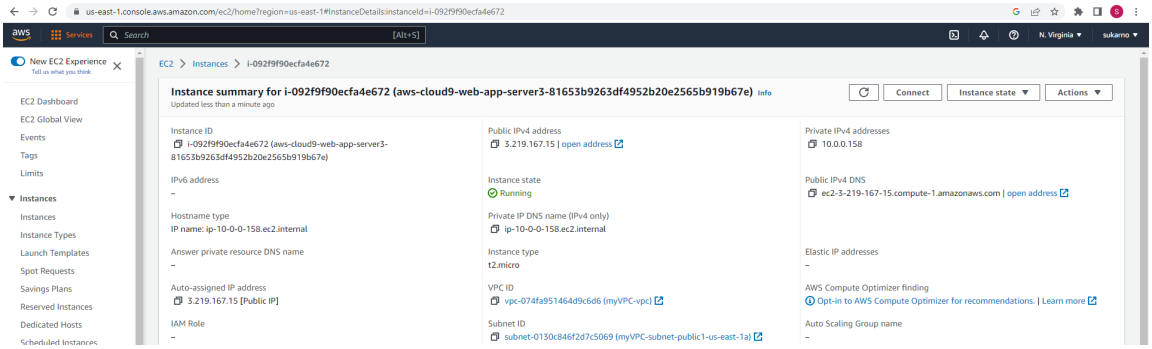


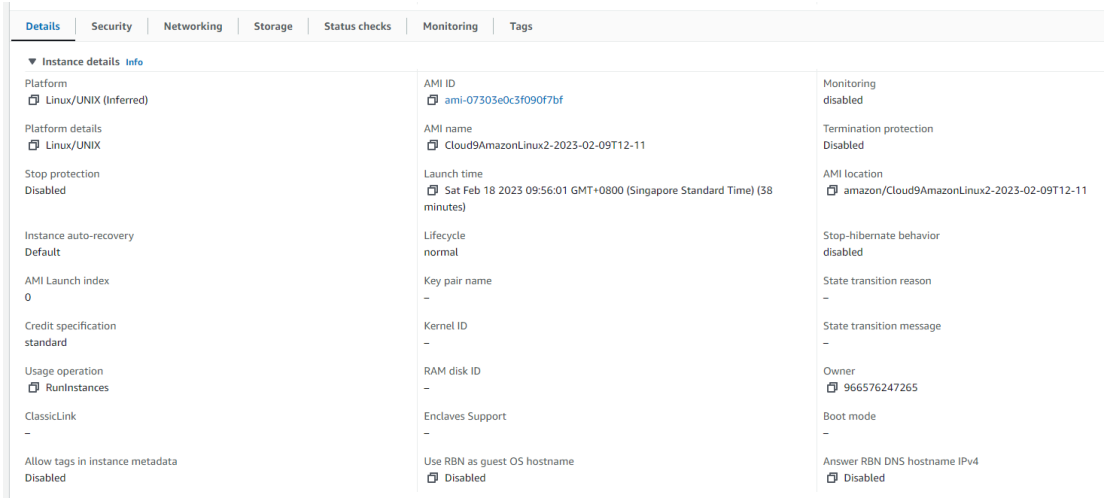


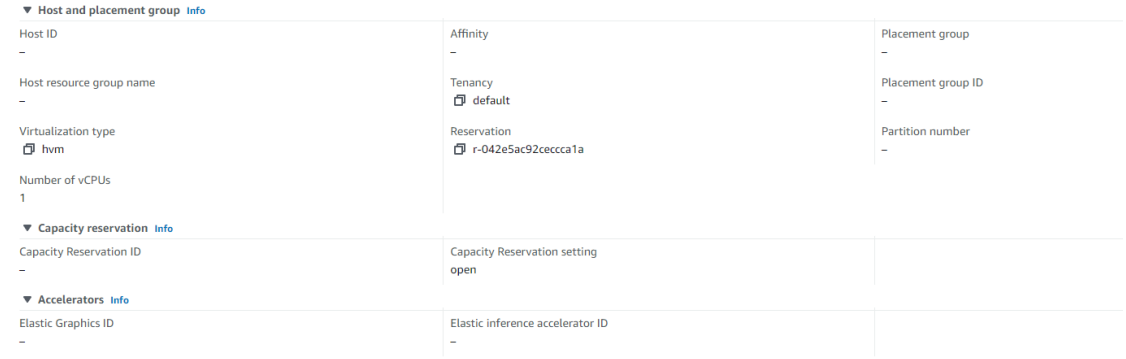
The snapshot of the Cloud9 is shown below, while the snapshot of the entire code is provided in Appendix.

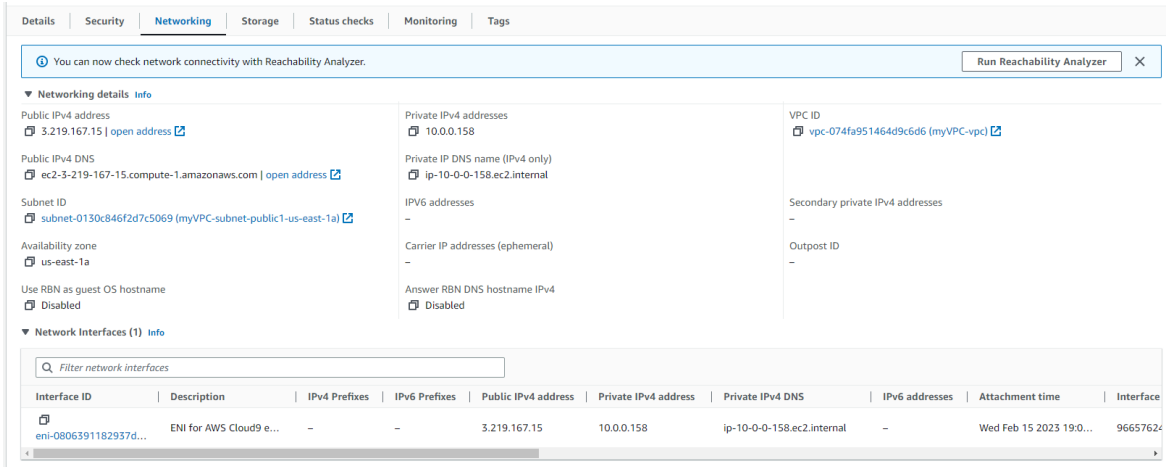


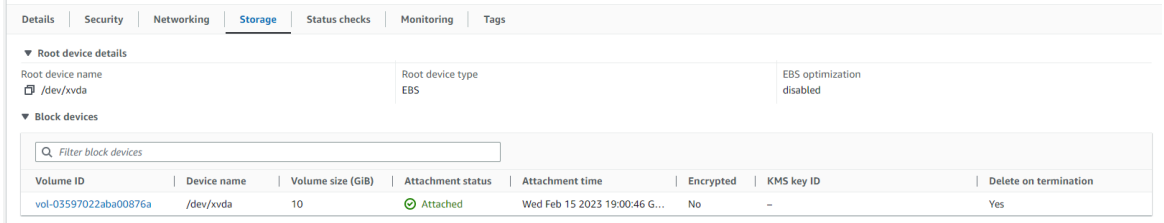
After the code development on Cloud9 is completed, an EC2 is automatically spin-off, as shown below.







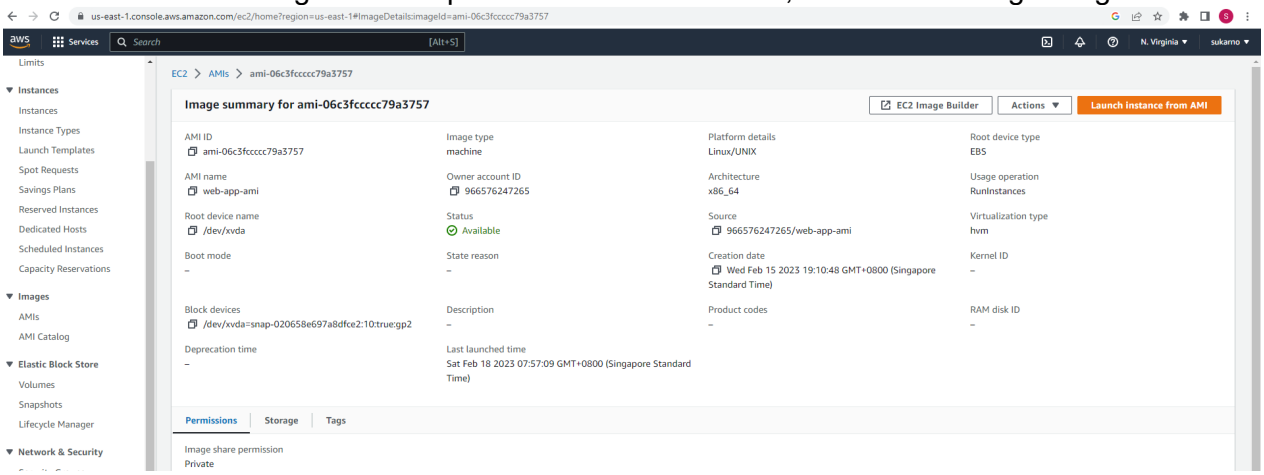


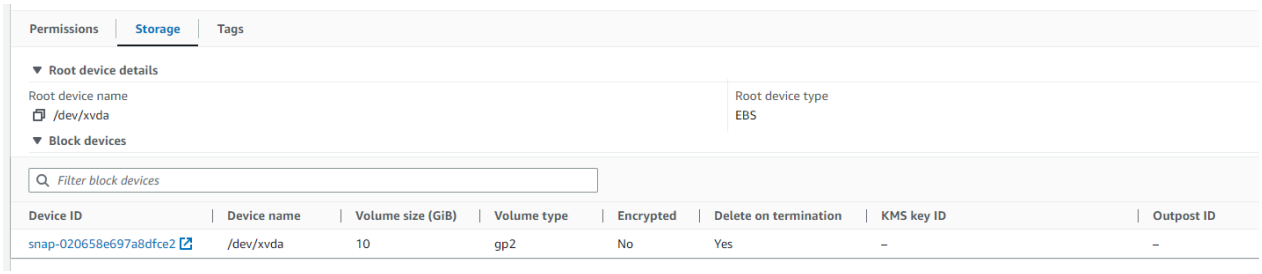


Security details have been provided in section 3 Security Design.

Step 3: Create an Image using the EC2 spin off from Cloud9

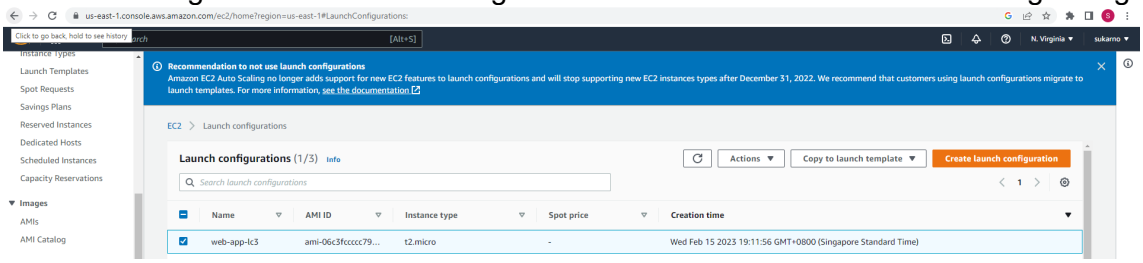
In order to allow Auto-Scaling Group to scale-out identical EC2 when there is an increase in traffic, an AMI is created using the EC2 spin off from Cloud9 earlier, with the following configuration:

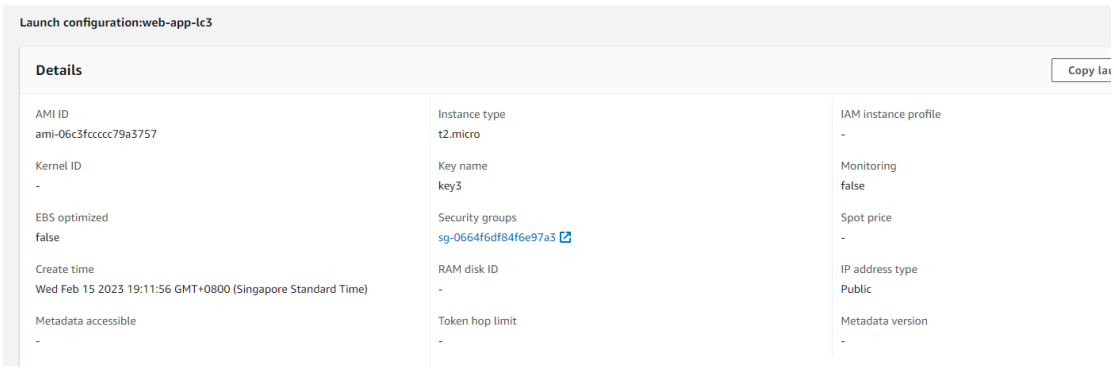




Step 4: Create Launch Configuration using AMI created earlier

A launch configuration is created using the AMI created earlier with the following configuration:





User data
-

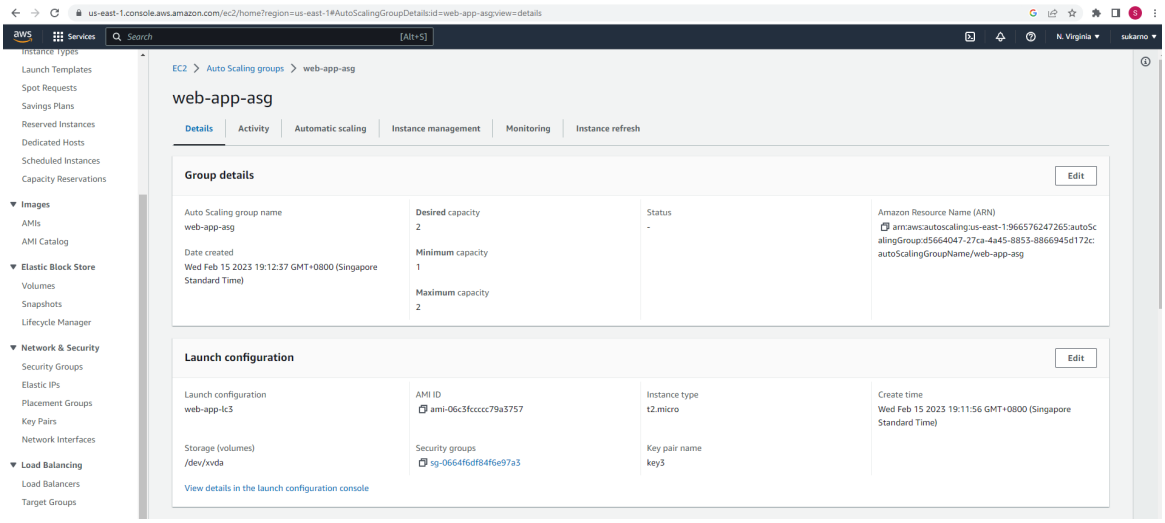
Storage (volumes)

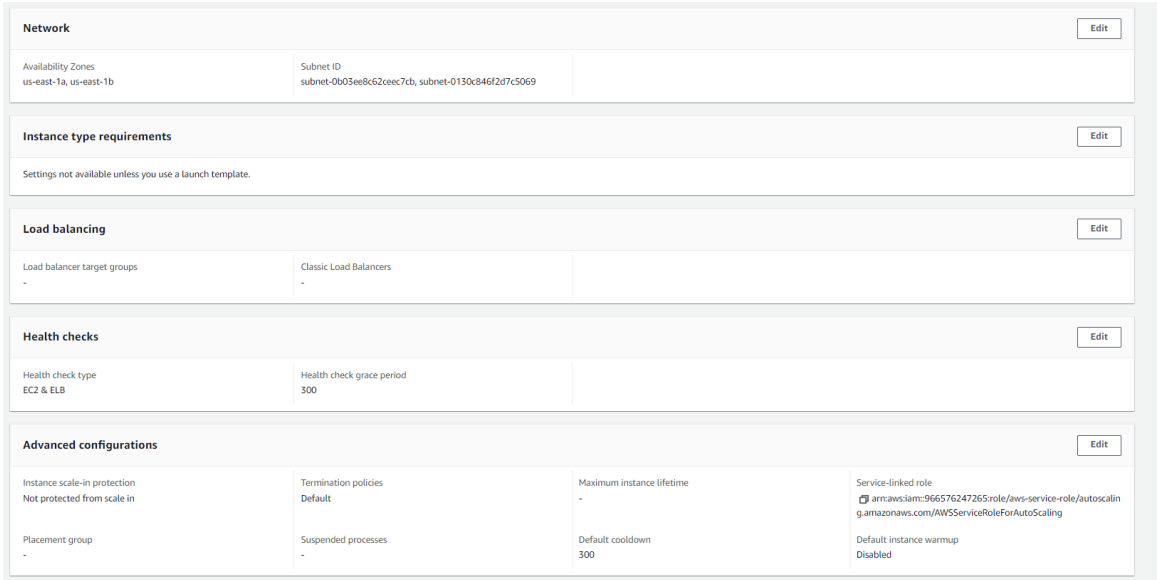
Search block devices

Block device	Size (GiB)	Type	IOPS	Throughput	Delete on termination	Encrypted
/dev/xvda	10	gp2	-	-	true	false

Step 5: Create Auto-Scaling Group

Auto-Scaling Group is afterwards created by using the Launch Configuration created earlier. The configuration is shown below:

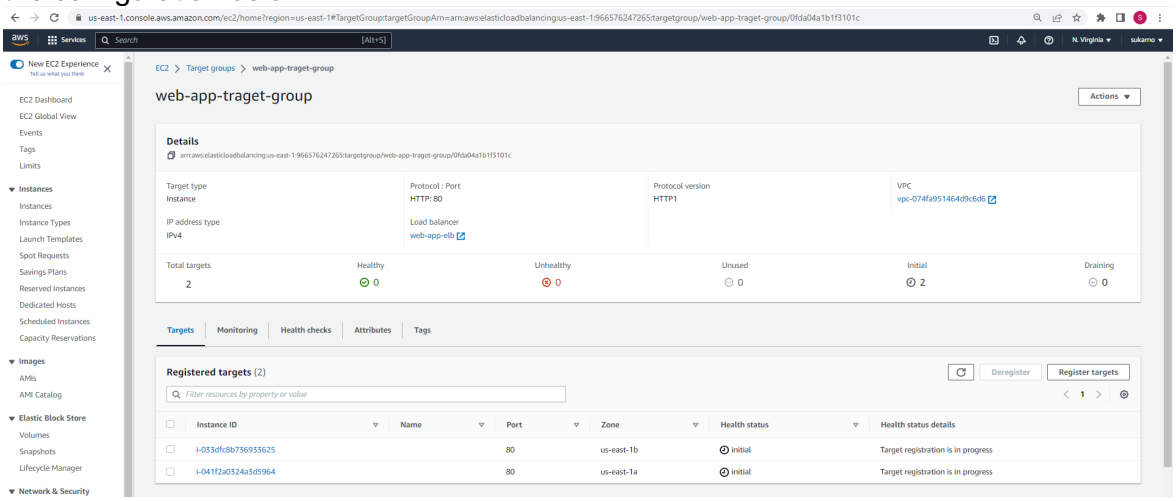




The minimum capacity is set to 1 and the maximum capacity is set to 2. Therefore, the number of EC2 will increase from 1 to 2 when there is an increase in website traffic. EC2 and ELB health check are performed every 300 seconds.

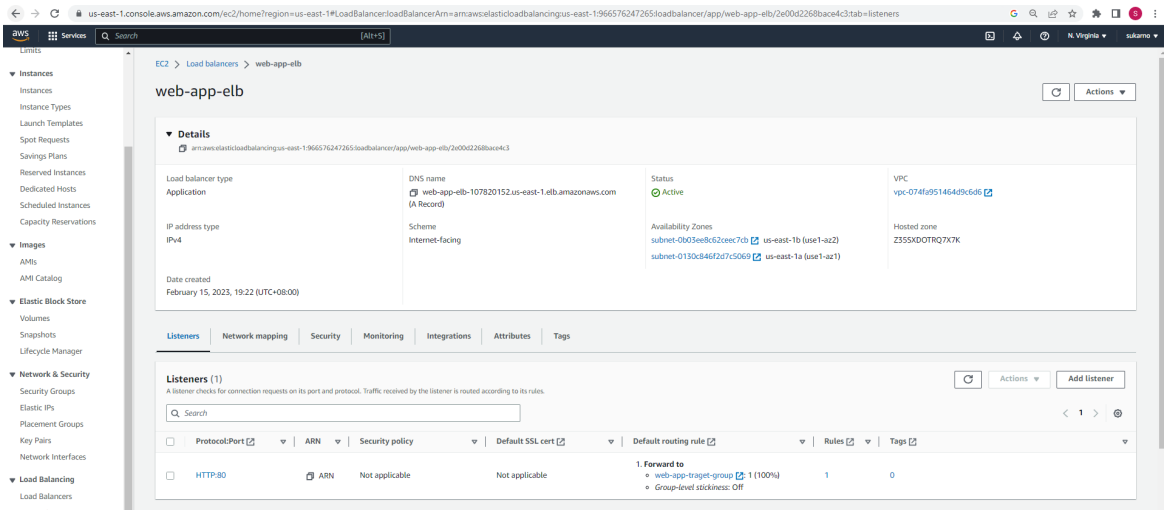
Step 6: Create Target Group

After the EC2 is spin-off using Auto-Scaling Group, they are registered inside the target group with the configuration below:

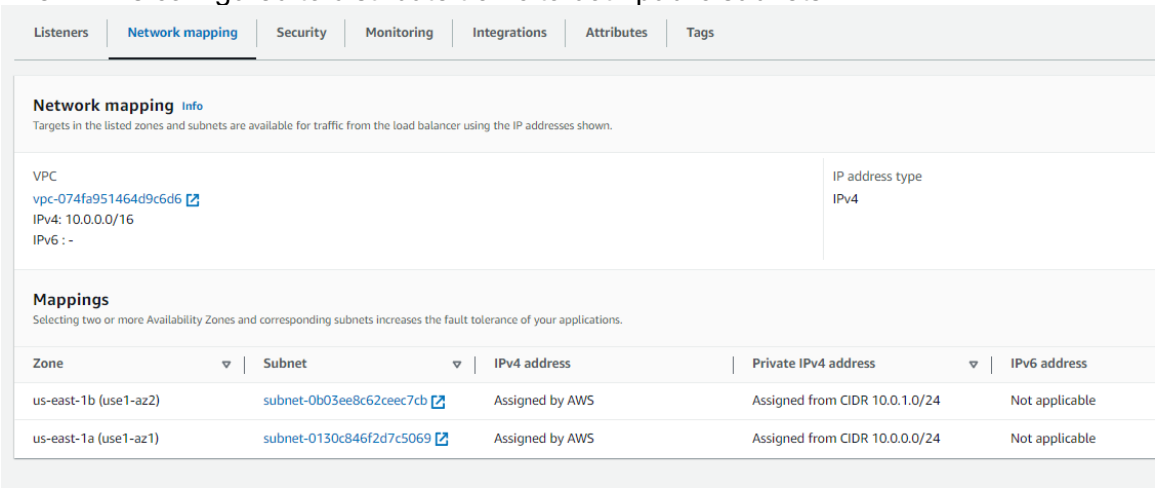


Step 7: Create Elastic Load Balancer

Now configure the ELB using the target group created earlier:

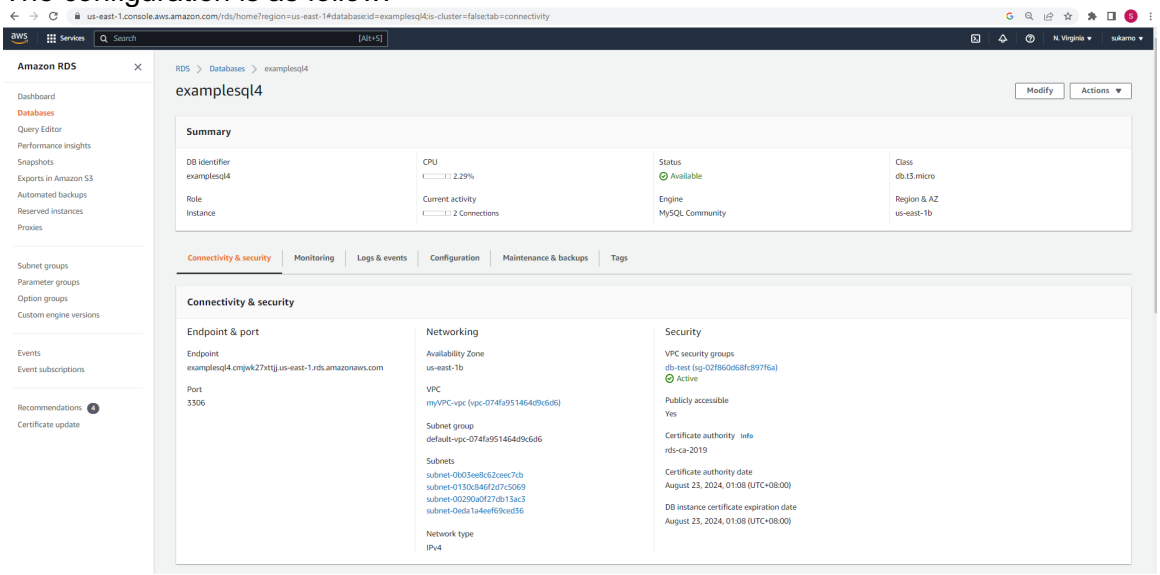


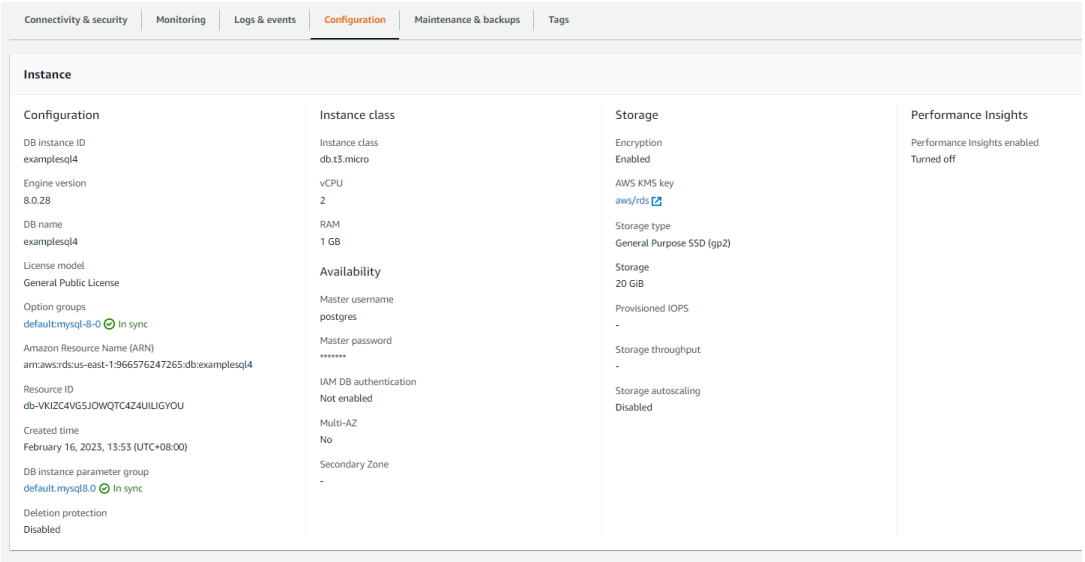
The ELB is configured to distribute traffic to both public subnets:



Step 8: Create RDS instance

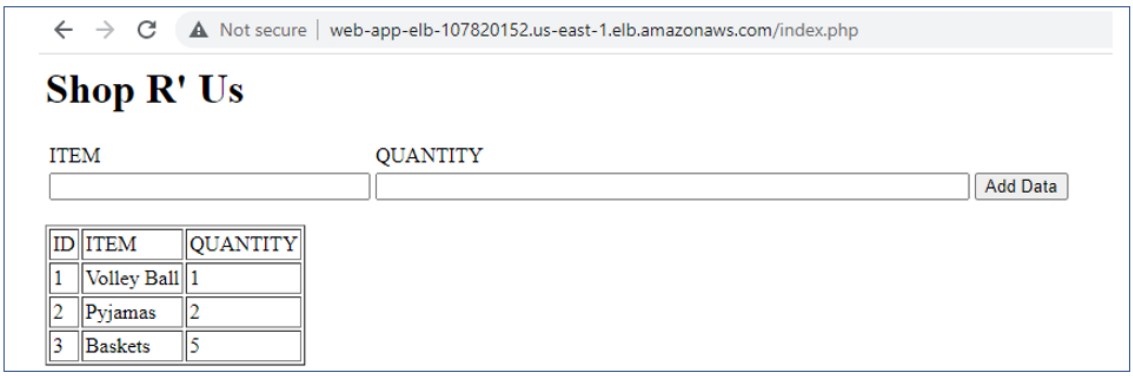
The configuration is as follow:





Db.t3.micro is selected because AWS Free Tier is used to create this project. In reality the instance class is db.m1.small.
The security details are provided in Section 4.

Step 9: Test run the website using ELB Public DNS Address

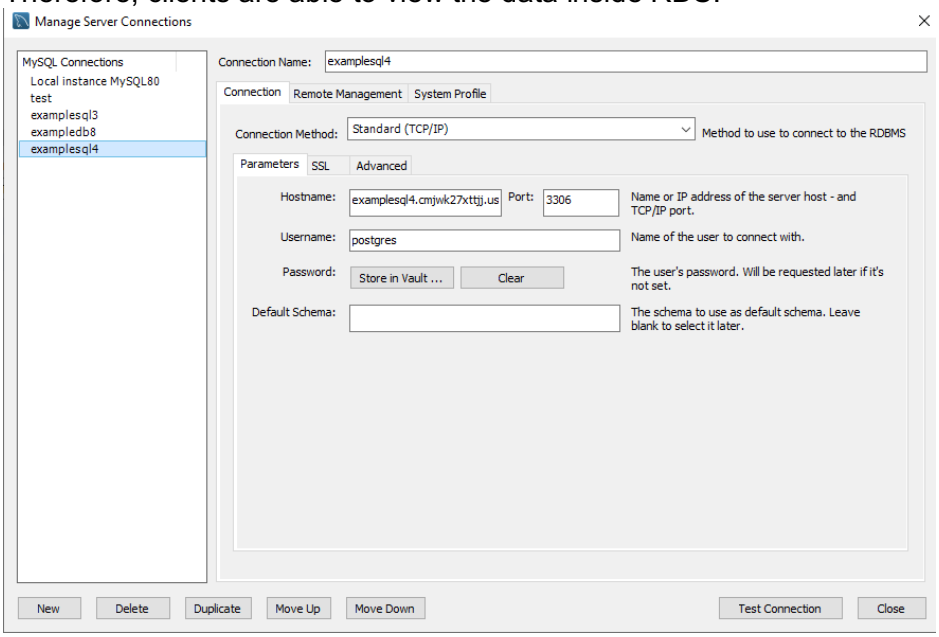


(Nguyen, 2018)

As an illustration, the shoppers are able to add items and their quantities they wish to buy.

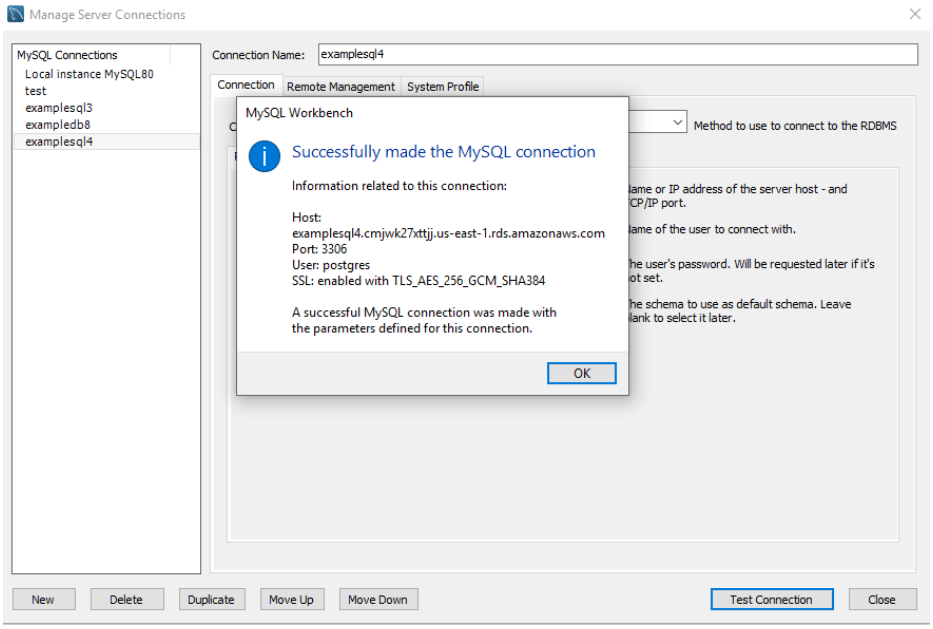
Step 10: Connect MySQL bench to RDS

MySQL workbench (in local machine) is connected to RDS using RDS endpoint, as shown below. Therefore, clients are able to view the data inside RDS.



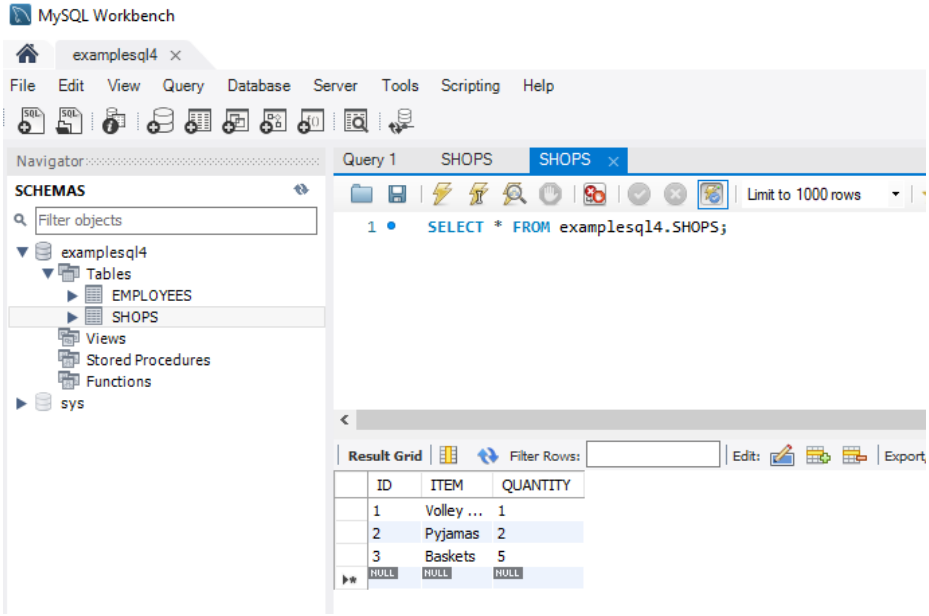
(MySQL, 2023)

Test the connection



(MySQL, 2023)

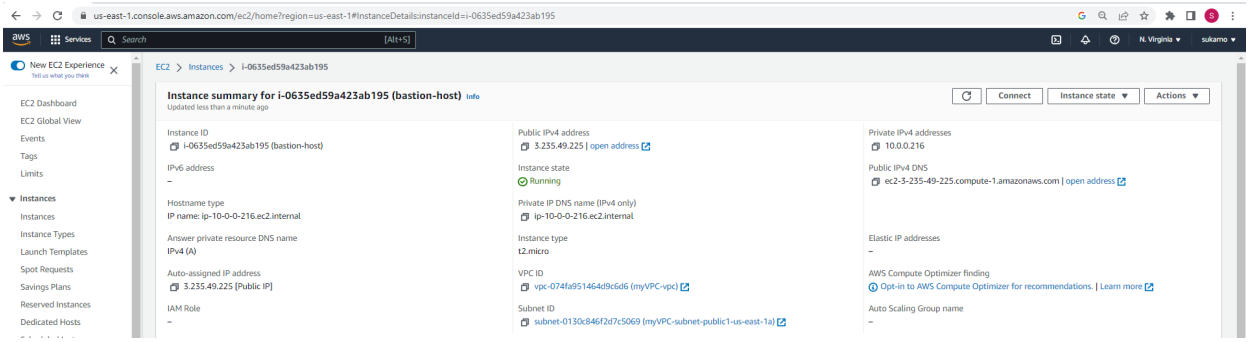
Use ‘Select * from examplesql4.SHOPS’ to display all data.

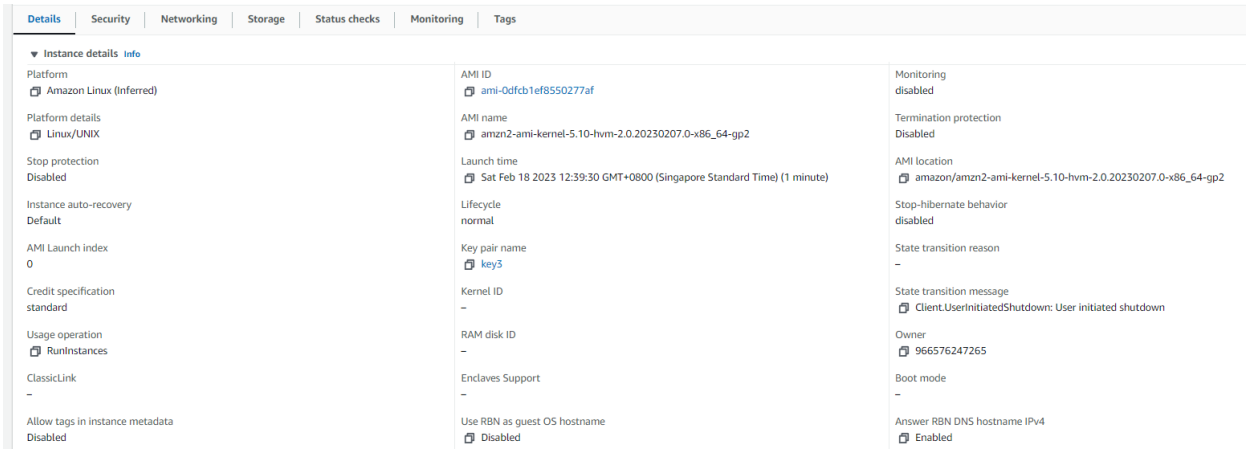


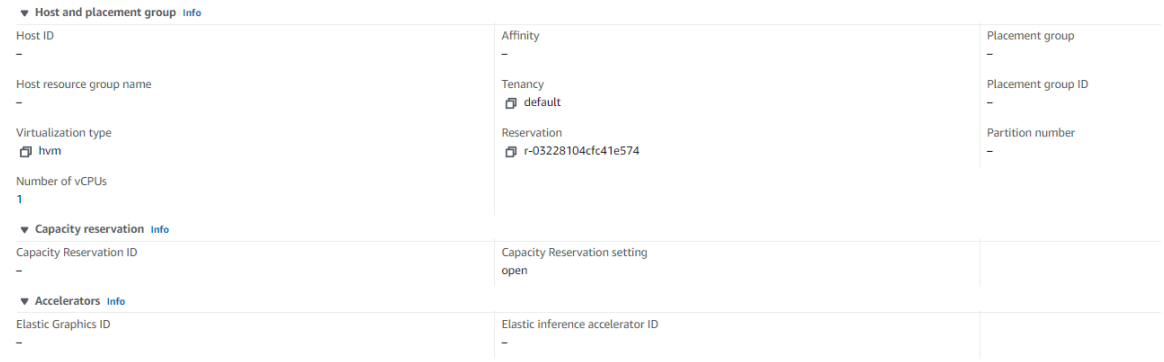
(MySQL, 2023)

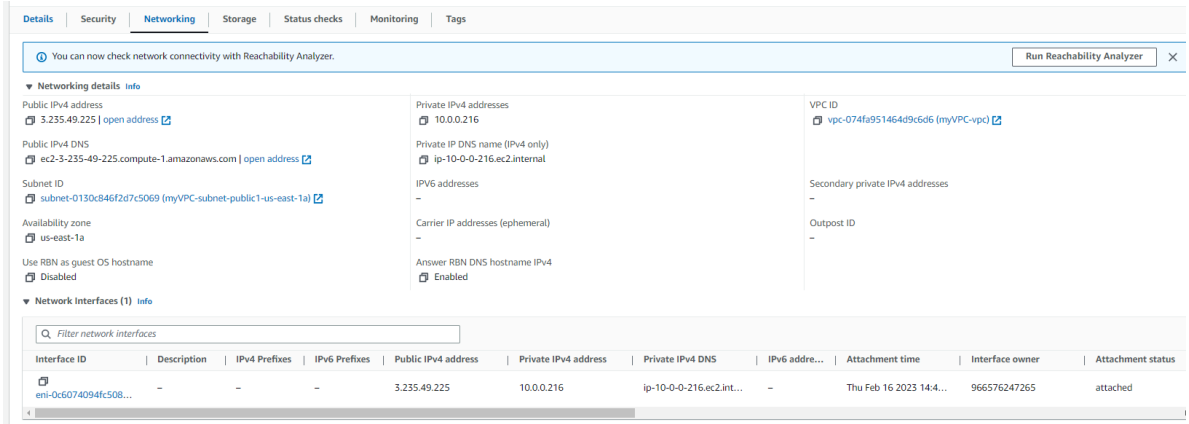
Step 11: Add Bastion Host

Bastion Host is added to allow local terminal to use SSH (secure shell) to access to EC2 and RDS instance, with the configuration as follow:




Details
Security
Networking
Storage
Status checks
Monitoring
Tags
Instance details Info
Platform
Amazon Linux (Inferred)
Platform details
Linux/UNIX
Stop protection
Disabled
Instance auto-recovery
Default
AMI Launch index
0
Credit specification
standard
Usage operation
RunInstances
ClassicLink
–
Allow tags in instance metadata
Disabled
AMI ID
ami-0dfcb1ef8550277af
AMI name
amzn2-ami-kernel-5.10-hvm-2.0.20230207.0-x86_64-gp2
Launch time
Sat Feb 18 2023 12:39:30 GMT+0800 (Singapore Standard Time) (1 minute)
Lifecycle
normal
Key pair name
key3
Kernel ID
–
RAM disk ID
–
Enclaves Support
–
Use RBN as guest OS hostname
Disabled
Monitoring
disabled
Termination protection
Disabled
AMI location
amazon/amzn2-ami-kernel-5.10-hvm-2.0.20230207.0-x86_64-gp2
Stop-hibernate behavior
disabled
State transition reason
–
State transition message
Client.UserInitiatedShutdown: User initiated shutdown
Owner
966576247265
Boot mode
–
Answer RBN DNS hostname IPv4
Enabled


Host and placement group Info
Host ID
–
Host resource group name
–
Virtualization type
hvm
Number of vCPUs
1
Affinity
–
Tenancy
default
Reservation
r-03228104cfc41e574
Placement group
–
Placement group ID
–
Partition number
–
Capacity reservation Info
Capacity Reservation ID
–
Capacity Reservation setting
open
Accelerators Info
Elastic Graphics ID
–
Elastic inference accelerator ID
–


Details
Security
Networking
Storage
Status checks
Monitoring
Tags
You can now check network connectivity with Reachability Analyzer.
Run Reachability Analyzer
Networking details Info
Public IPv4 address
3.235.49.225 | open address
Public IPv4 DNS
ec2-3-235-49-225.compute-1.amazonaws.com | open address
Subnet ID
subnet-0130c846f2d7c5069 (myVPC-subnet-public1-us-east-1a)
Availability zone
us-east-1a
Use RBN as guest OS hostname
Disabled
Private IPv4 addresses
10.0.0.216
Private IP DNS name (IPv4 only)
ip-10-0-0-216.ec2.internal
IPV6 addresses
–
Carrier IP addresses (ephemeral)
–
Answer RBN DNS hostname IPv4
Enabled
VPC ID
vpc-074fa951464d9c6d6 (myVPC-vpc)
Secondary private IPv4 addresses
–
Outpost ID
–
Network Interfaces (1) Info
Filter network interfaces
Interface ID
Description
IPv4 Prefixes
IPv6 Prefixes
Public IPv4 address
Private IPv4 address
Private IPv4 DNS
IPv6 addre...
Attachment time
Interface owner
Attachment status
eni-0c6074094fc508...
–
–
–
3.235.49.225
10.0.0.216
ip-10-0-0-216.ec2.int...
–
Thu Feb 16 2023 14:4...
966576247265
attached

Step 12: Test Bastion Host

- Download the PEM key (key3.pem) from AWS.
- Connect to bastion host using key3.pem and bastion endpoint.
  Run chmod 400 beforehand to allow access of pem key.

```
(base) sukarno.zhanggmail.com@Sukarnos-MacBook-Pro rp % chmod 400 key3.pem
(base) sukarno.zhanggmail.com@Sukarnos-MacBook-Pro rp % ssh -i key3.pem ec2-user@ec2-44-192-89-145.compute-1.amazonaws.com

       __|  __|_  )
       _|  (     /   Amazon Linux 2 AMI
      ___|\___|___|

https://aws.amazon.com/amazon-linux-2/
-bash: warning: setlocale: LC_CTYPE: cannot change locale (UTF-8): No such file or directory
[ec2-user@ip-10-0-0-216 ~]$
```

- Create a new pem key called “new.pem”, the contents are identical to key3.pem.
  Upload new.pem to bastion host using bastion endpoint

```
(base) sukarno.zhanggmail.com@Sukarnos-MacBook-Pro rp % scp -i key3.pem new.pem ec2-user@ec2-44-192-89-145.compute-1.amazonaws.com:
/etc/profile.d/lang.sh: line 19: warning: setlocale: LC_CTYPE: cannot change locale (UTF-8): No such file or directory
new.pem                                       100% 1674     5.1KB/s   00:00
(base) sukarno.zhanggmail.com@Sukarnos-MacBook-Pro rp %
```

- Use new.pem and web-app EC2 endpoint to connect to web-app EC2 from bastion host

```
[ec2-user@ip-10-0-0-216 ~]$ ssh -i new.pem ec2-user@ec2-3-86-97-47.compute-1.amazonaws.com
The authenticity of host 'ec2-3-86-97-47.compute-1.amazonaws.com (10.0.1.80)' can't be established.
ECDSA key fingerprint is SHA256:tbDsVCt7n6ob/yk4Scjer65nIBI5NNvHLrWkYZDjLdQ.
ECDSA key fingerprint is MD5:f7:f2:81:07:ac:b4:e1:50:94:b7:30:8b:98:04:5f:14.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added 'ec2-3-86-97-47.compute-1.amazonaws.com,10.0.1.80' (ECDSA) to the list of known hosts.

       __|  __|_  )
       _|  (     /   Amazon Linux 2 AMI
      ___|\___|___|

https://aws.amazon.com/amazon-linux-2/
No packages needed for security; 1 packages available
Run "sudo yum update" to apply all updates.
manpath: can't set the locale; make sure $LC_* and $LANG are correct
:~ $
```

- Inside web-app tier, CD into /var/www/html/ and check if the php file is inside

```
:~ $ ls
environment  node_modules  package-lock.json  package.json
:~ $ cd /var/www/html
:/var/www/html $ ls
index.php
:/var/www/html $
```

index.php file developed earlier was found inside /var/www/html/

- Connect to RDS using RDS endpoint

```
:~ $ mysql -u postgres -p --host examplesql4.cmjwk27xttjj.us-east-1.rds.amazonaws.com
Enter password:
Welcome to the MariaDB monitor.  Commands end with ; or \g.
Your MySQL connection id is 65
Server version: 8.0.28 Source distribution

Copyright (c) 2000, 2018, Oracle, MariaDB Corporation Ab and others.

Type 'help;' or '\h' for help. Type '\c' to clear the current input statement.

MySQL [(none)]>
```

- Show the databases

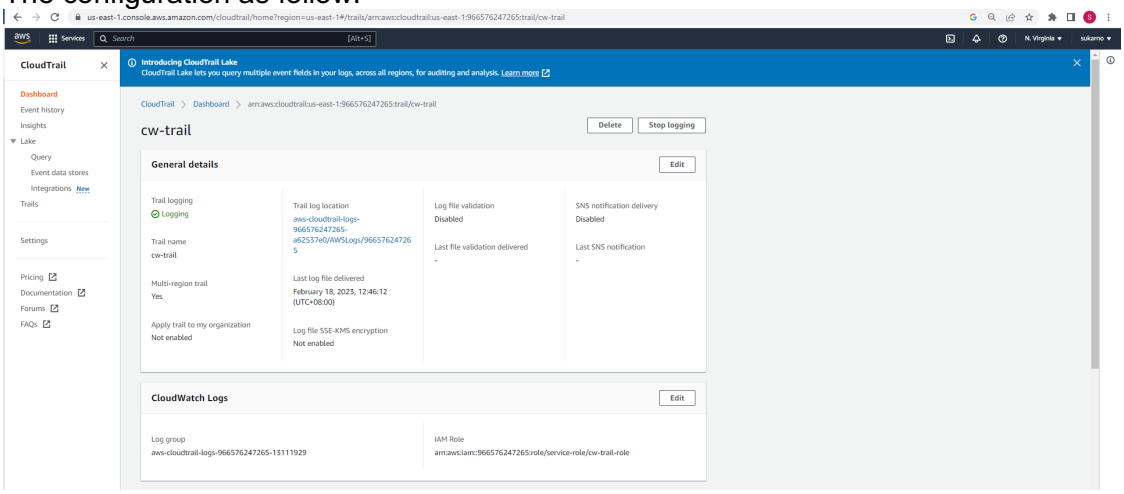
```
MySQL [(none)]> show databases;
+--------------------+
| Database           |
+--------------------+
| examplesql4        |
| information_schema |
| mysql              |
| performance_schema |
| sys                |
+--------------------+
```

- Finally, display the contents inside the SHOPS table

```
MySQL [examplesql4]> select * from SHOPS;
+----+---------+----------+
| ID | ITEM    | QUANTITY |
+----+---------+----------+
|  1 | Monitor | 1        |
+----+---------+----------+
1 row in set (0.00 sec)
```

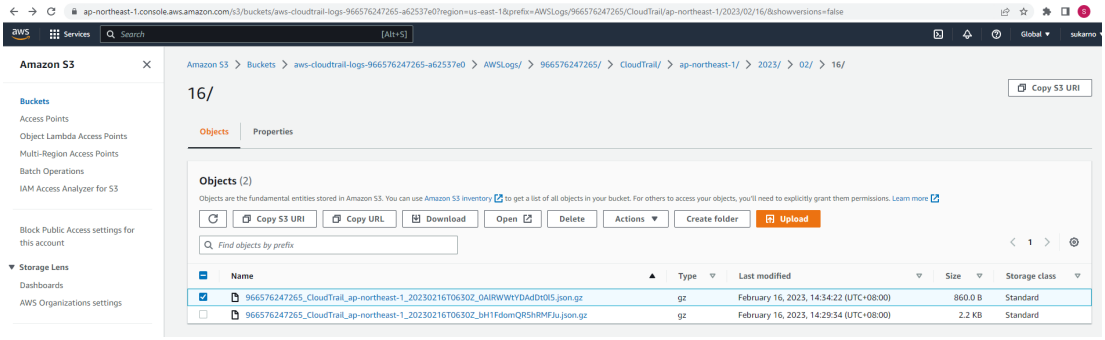
Step 13: Add Cloud Trail

The configuration as follow:

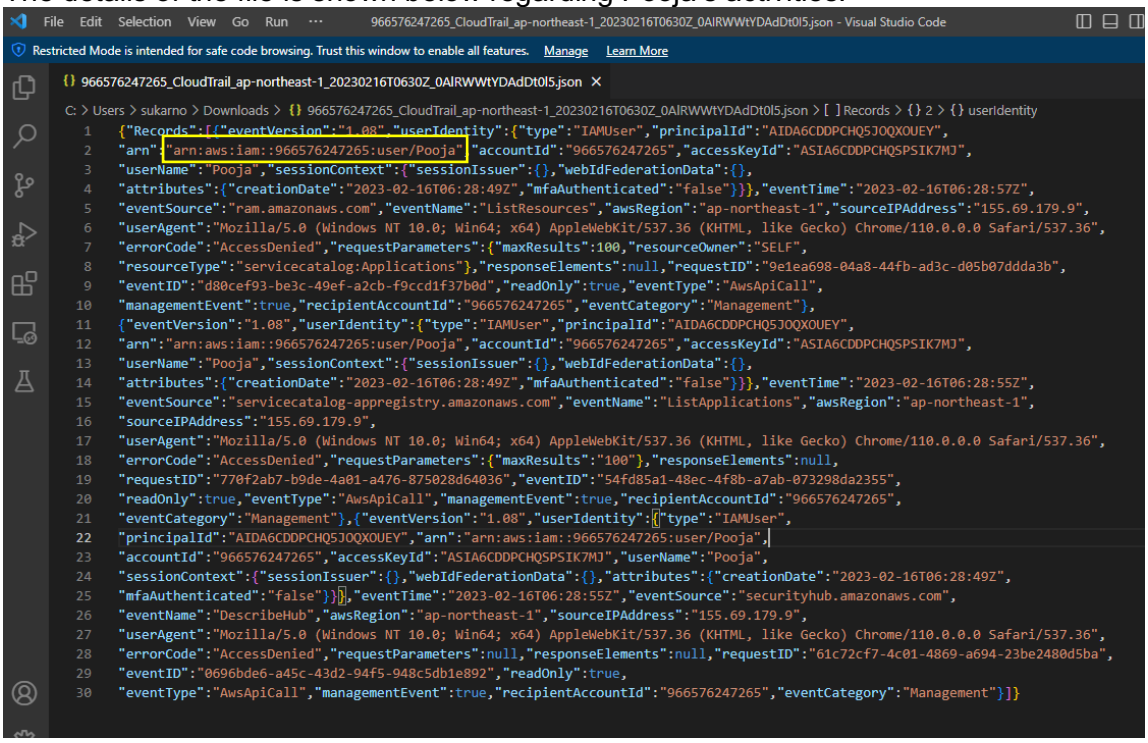


Step 14: Test Cloud Trail

When the user “Pooja” created in IAM do a login into AWS console, a new logging details are provided in the S3 bucket.



The details of the file is shown below regarding Pooja’s activities:



6. Conclusions

To host website for Shop R' Us, a single VPC was created. Two Availability Zones (AZs) are built in the VPC hence the website is highly available. In another word, when one AZ is down, there will be a back up in another AZ. In each AZ, there is a public and private subnet. The public subnet hosts the web and application server in general, while database is hosted in the private subnet to enhance security. There is an elastic load balancer to distribute traffic into 2 AZs, while the Auto-Scaling is used to scale-in or scale out web-app EC2 accordingly. In addition, bastion host is added to allow admin to access to EC2 and RDS securely from local terminal using SSH (secure shell). Finally, AWS CloudTrail is added to monitor activities of different users.

Since this is an open-ended assignment, an overall high-level understanding of the AWS Cloud Architecting teaching materials and labs are required to successfully complete this project. Hence a revision of learning materials and labs are required when I encountered configurations error on AWS console. Due to the number of restrictions implemented in AWS Leaner environment, AWS Free Tier is used to complete this assignment instead. Therefore, an extra caution is required to avoid exorbitant costs. However, this has also honed my skills in budget planning when designing and configuring the instances on AWS Free Tier console.

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