

CCT College Dublin

Assessment Cover Page

Module Title:	Cloud Services
Assessment Title:	Implementing a proof-of-concept cloud architecture
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Q:1(a) Clouds-Are-Us: Setup a static website

- In Services, navigate S3, select Buckets and hit Create bucket.
- I gave bucket name as my-cloudareus-2021384.

Create bucket [Info](#)

Buckets are containers for data stored in S3.

General configuration

AWS Region
US East (N. Virginia) us-east-1

Bucket type [Info](#)

☒ **General purpose**
Recommended for most use cases and access patterns. General purpose buckets are the original S3 bucket type. They allow a mix of storage classes that redundantly store objects across multiple Availability Zones.

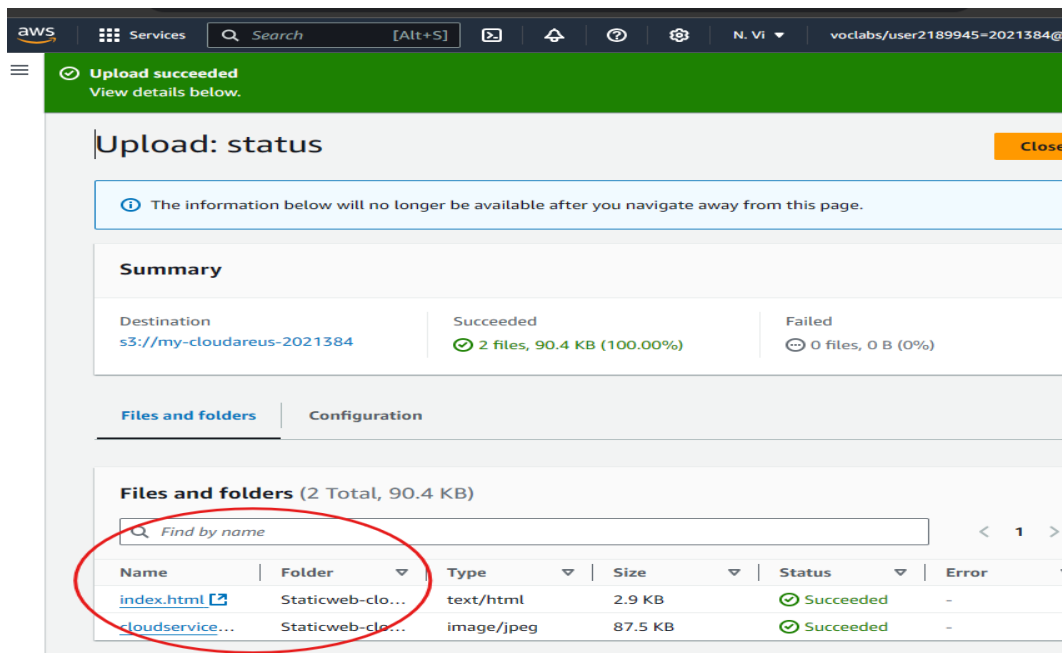
☐ **Directory**
Recommended for low-lat use only the S3 Express Outposts provides faster processing Availability Zone.

Bucket name [Info](#)
my-cloudareus-2021384

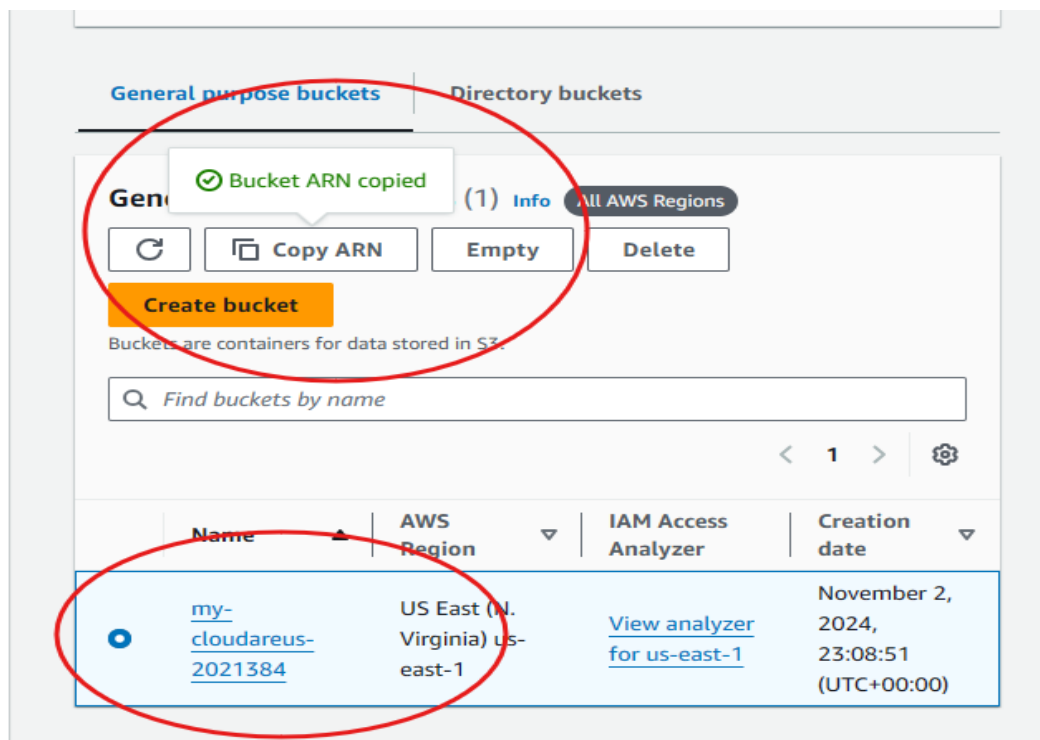
Bucket name must be unique within the global namespace and follow the bucket naming rules. [See rule](#)

~~Copy settings from existing bucket - optional~~
Only the bucket settings in the following configuration are copied.

- Inside the bucket, I uploaded my custom made index.html page of cloud-are-us website and image folder.



- Copy the ARN of my-cloudareus-2021384 bucket for modification in bucket policy script.




- Go to Permissions, inside the bucket.
- Edit Bucket public access setting.

Amazon S3 > Buckets > my-cloudareus-2021384

my-cloudareus-2021384 Info


< | Objects | Properties | **Permissions** | Metrics | Mana | >

Permissions overview

Access finding
Access findings are provided by IAM external access analyzers. Learn more about [How IAM analyzer findings work](#) 
[View analyzer for us-east-1](#)


Block public access (bucket settings)

Public access is granted to buckets and objects through access control lists (ACLs), bucket policies, access point policies, or all. In order to ensure that public access to all your S3 buckets and objects is blocked, turn on Block all public access. These settings apply only to this bucket and its access points. AWS recommends that you turn on Block all public access, but before applying any of these settings, ensure that your applications will work correctly

Edit 

- Untick all block access section publicly.

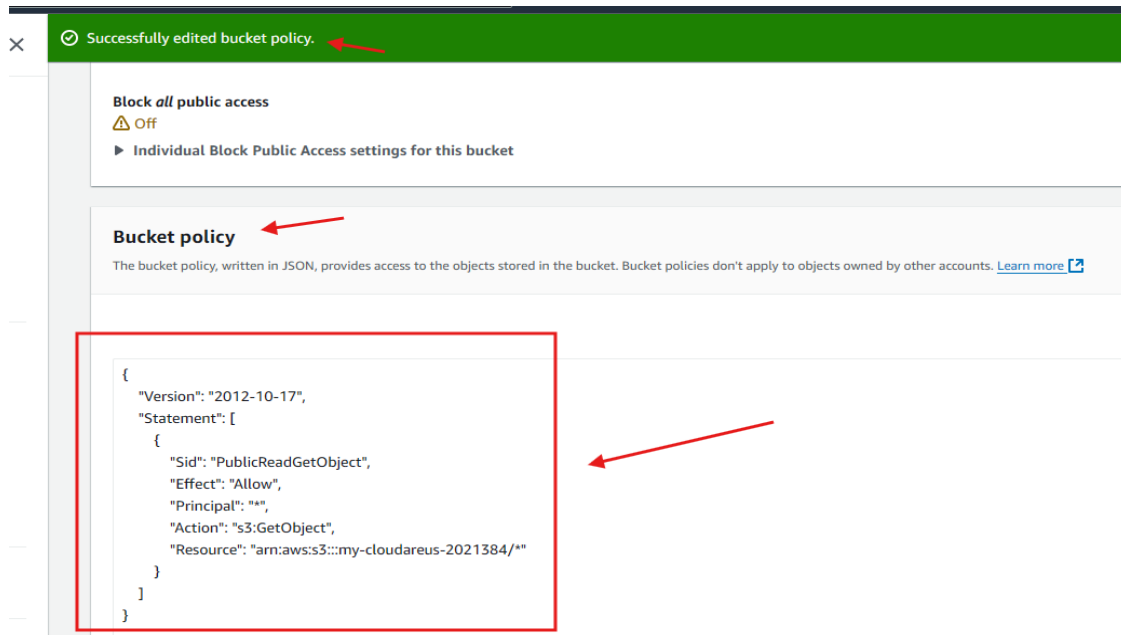
Block public access (bucket settings)

Public access is granted to buckets and objects through access control lists (ACLs), bucket policies, access point policies, or all. In order to ensure that public access to all your S3 buckets and objects is blocked, turn on Block all public access. These settings apply only to this bucket and its access points. AWS recommends that you turn on Block all public access, but before applying any of these settings, ensure that your applications will work correctly without public access. If you require some level of public access to your buckets or objects within, you can customize the individual settings below to suit your specific storage use cases. [Learn more](#) 

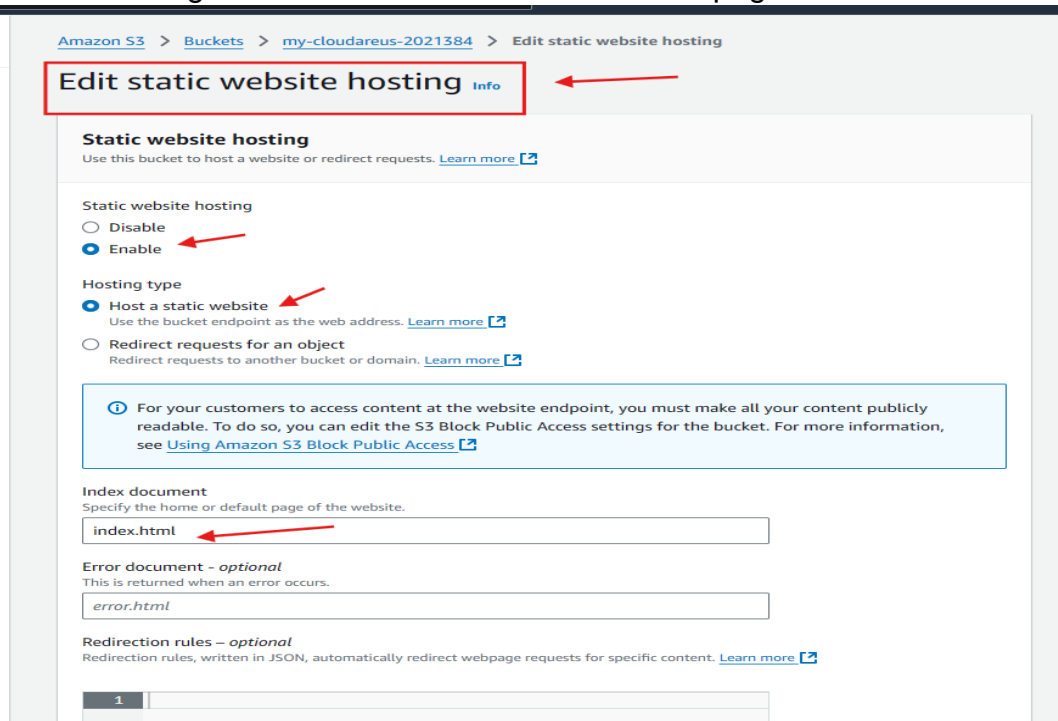
☐ **Block all public access**
Turning this setting on is the same as turning on all four settings below. Each of the following settings are independent of one another.

- ☐ **Block public access to buckets and objects granted through new access control lists (ACLs)**
S3 will block public access permissions applied to newly added buckets or objects and prevent the creation of new public access ACLs for existing buckets and objects. This setting doesn't change any existing permissions that allow public access to resources using ACLs.
- ☐ **Block public access to buckets and objects granted through any access control lists (ACLs)**
S3 will ignore all ACLs that grant public access to buckets and objects.
- ☐ **Block public access to buckets and objects granted through new public bucket or access point policies**
S3 will block new bucket and access point policies that grant public access to buckets and objects. This setting doesn't change any existing policies that allow public access to S3 resources.
- ☐ **Block public and cross-account access to buckets and objects**

- After that, Edited Bucket Policy by adding the script inside the policy with bucket ARN.



- Now, Go to properties of bucket.
- Edited the static website hosting and enable it.
- Set on hosting a static website and set the default page as index.html.



- Copy the URL of index.html file inside the bucket and search it on browser.

Amazon S3 > ... > my-cloudareus-2... > Staticweb-clouds-... > index.html

index.html Info

[Copy S3 URI](#) [Download](#) [Open](#)

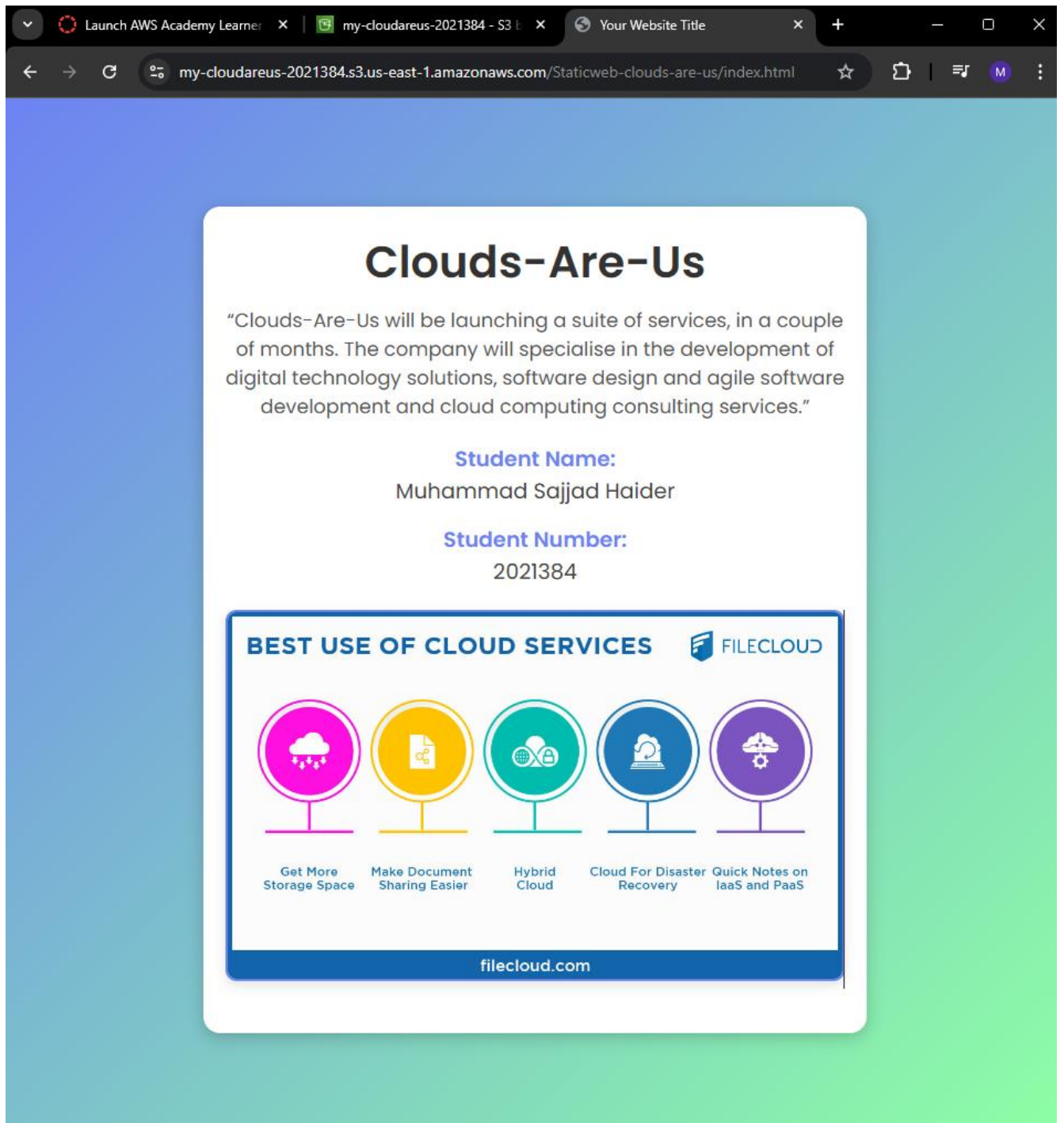
Object actions ▼

[Properties](#) | [Permissions](#) | [Versions](#)

Object overview

Owner	awslabsc0w6203871t1693415066	S3 URI	s3://my-cloudareus-2021384/Staticweb-clouds-are-us/index.html
AWS Region	US East (N. Virginia) us-east-1	Amazon Resource Name (ARN)	arn:aws:s3:::my-cloudareus-2021384/Staticweb-clouds-are-us/index.html
Last modified	November 2, 2024, 23:10:01 (UTC+00:00)	Entity tag (Etag)	ac3ca65309e8eb25a17b7eed3fce4f07
Size	2.9 KB	Object URL	https://my-cloudareus-2021384.s3.us-east-1.amazonaws.com/Staticweb-clouds-are-us/index.html
Type	html		
Key	Staticweb-clouds-are-us/index.html		

- It can be seen that Cloud-Are-Us website is successfully working with my name and student number in shot below:



Q:1(b):Research Task: Comparison of S3 & EC2 with EBS

The type of data that can be stored and the utility of the two Amazon services, S3 and EC2 coupled with EBS differ as well. These two kinds of storage options are compared

in detail in this representation: how they are alike, how they differ, and where they are suitable for use.

Type of Storage:

S3: Object storage designed to be available, scalable and most importantly built to be durable. It stores data as objects using buckets.

For objects that want to hook up directly to an EC2 instance and works like a regular hard drive, there is EBS stands for Elastic Block Storage with storage volumes at block level available for provision.

Data Structure:

S3: In this model, the data is stored in objects which contain a reference number, some type of information about the piece of data, and the actual data. Depending on the size it is possible that everything up to and including 5TB.

EBS: Blocks of data are arranged. Volumes are attached to EC2 instances by direct connection, and they can be scaled up to a 64TB throughput.

Patterns of Access:

For the large amounts of structured, semi-structured, and unstructured data in:

S3: It is suitable for occasional or unpredictable use, distribution of print media, such as newsletters, and any form of content that is not frequently updated.

EBS: Meant for workloads such as databases or file systems that regularly write and read data out on their storage device. Specifically, it is designed for low latency access.

Availability and Durability:

S3: offers the availability and the durability of 99.999999999% (11 nines) in many geographical regions. Database replication occurs and it just happens in the background.

EBS: It provides 99.999% durability; however, it comes with the provision of availability zone only. For redundancy, they can take the so-called snapshot.

Costs:

S3: Bill is based on traffic associated with operations such as requests and amount of data transferred, stored, and used. So, it can be economically reasonable for big data sets.

EBS: Account cost is derived from IOPS (input/output operations per second) and volume size. However, the level of high performance may only be achieved at a higher cost.

Similarities:

S3 and EBS both have the provision of scalability. They achieved scalability in quite opposite manner. S3 is bucket can be manually resized while EBS automatically scales itself in response to usage.

Security:

Both have some of the analyzed features such as encryption data in transport and in storage, access through IAM policies, and compliance with several standards.

Applications Use Cases for Amazon S3

Data Lakes:

Storing massive amounts of raw data for AI processing and use for machine learning and big data computing.

Static Website Hosting:

Deliver, HTML based, CSS based, image-based static content.

Backup and Restore:

Coping with data, databases and on-premise applications back up.

Media Storage and Streaming:

Availing apps with the use of audio files, videos and other media.

Applications Use Cases Amazon EBS

Database Storage:

where you are executing low latency relational databases like PostgreSQL and MySQL.

File Systems:

Extending hosting for file systems which have to be stable and performant synchronously.

Development and Testing:

Charging programmers with the task of establishing scenarios in which they should launch and terminate instances as quickly as possible.

Q2(a): Application Load Balancer (ALB) with 5 Linux and Custom VPC

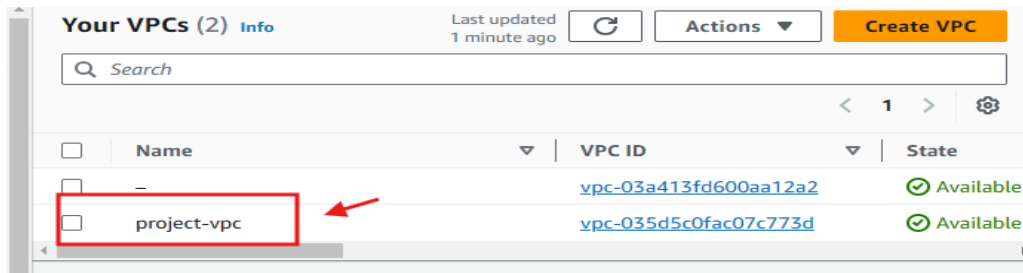
Creation of Custom VPC:

- Navigate VPC, from services and click create VPC.
- Selected VPC and more and gave name project.
- Select 2 Availability Zones (AZs) with two public subnets and two private subnets and stick with S3 Gateway.
- Stick with Enable hostnames and resolution and create VPC.

The screenshot shows the AWS VPC console 'Create VPC' page. Red arrows point to the following configuration elements:

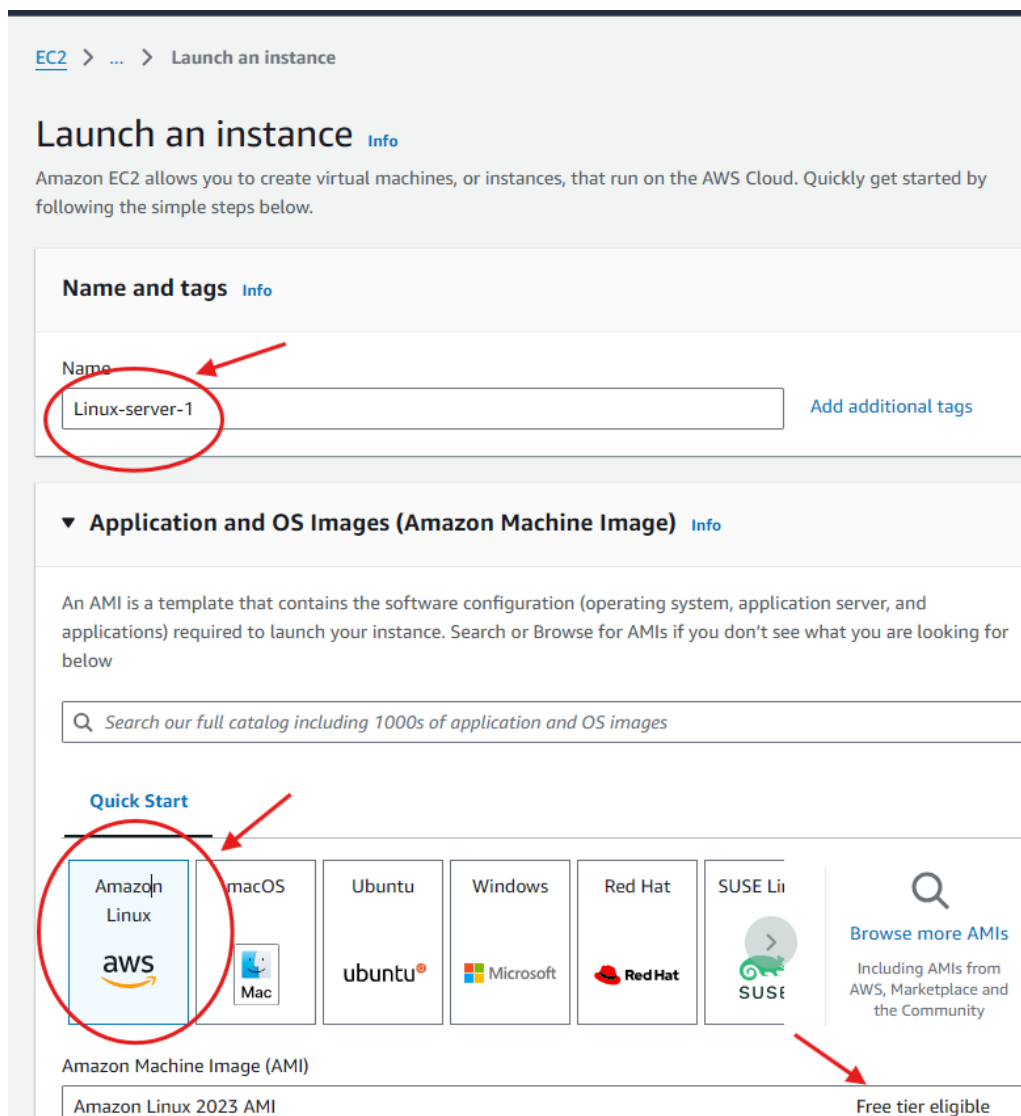
- Number of Availability Zones (AZs):** Set to 2 (labeled 'two AZs for high availability').
- Resources to create:** 'VPC and more' is selected.
- Name tag auto-generation:** 'Auto-generate' is checked, with the value 'project' entered.
- IPv4 CIDR block:** Set to '10.0.0.0/16'.
- IPv6 CIDR block:** 'No IPv6 CIDR block' is selected.
- Tenancy:** Set to 'Default'.
- Number of public subnets:** Set to 2.
- Number of private subnets:** Set to 4.
- NAT gateways (\$):** 'S3 Gateway' is selected.
- DNS options:** Both 'Enable DNS hostnames' and 'Enable DNS resolution' are checked.
- Create VPC button:** The 'Create VPC' button at the bottom right is circled in red.

- The new project-vpc has created successfully.



Creation of 5 Linux-servers:

- Navigate EC2, from services and click Launch instance.
- Gave names of all 5 instances as Linux-server-1, Linux-server-2, Linux-server-3, Linux-server-4 and Linux-server-5.
- Selected Amazon Linux as Amazon Machine Image (AMI).



- I create new pair with name Year4-2024-384-key with the type RSA and file format .ppk.

Create key pair

Key pair name
Key pairs allow you to connect to your instance securely.

Year4-2024-384-key

The name can include up to 255 ASCII characters. It can't include leading or trailing spaces.

Key pair type

☒ RSA
RSA encrypted private and public key pair

☐ ED25519
ED25519 encrypted private and public key pair

Private key file format

☐ .pem
For use with OpenSSH

☒ .ppk
For use with PuTTY

⚠ When prompted, store the private key in a secure and accessible location on your computer. You will need it later to connect to your instance. [Learn more](#)

Cancel Create key pair

- Selected Custom created project-vpc with the Public subnet.

▼ **Network settings** Info

VPC - required Info

vpc-035d5c0fac07c773d (project-vpc)
10.0.0.0/16

Subnet Info

subnet-0f0d22e6b14f2b4bd project-subnet-private2-us-east-1b
VPC: vpc-035d5c0fac07c773d Owner: 199428924135 Availability Zone: us-east-1b
Zone type: Availability Zone IP addresses available: 4091 CIDR: 10.0.144.0/20

Auto-assign public IP Info

Disable

Firewall (security groups) Info

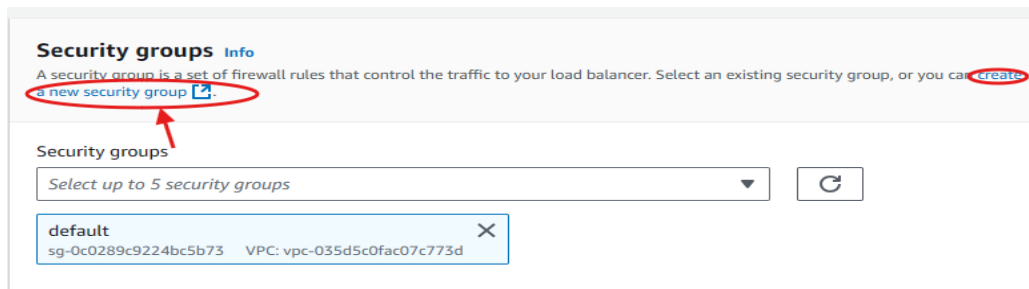
A security group is a set of firewall rules that control the traffic for your instance. Add rules to allow specific traffic to reach your instance.

☒ Create security group ☐ Select existing security group

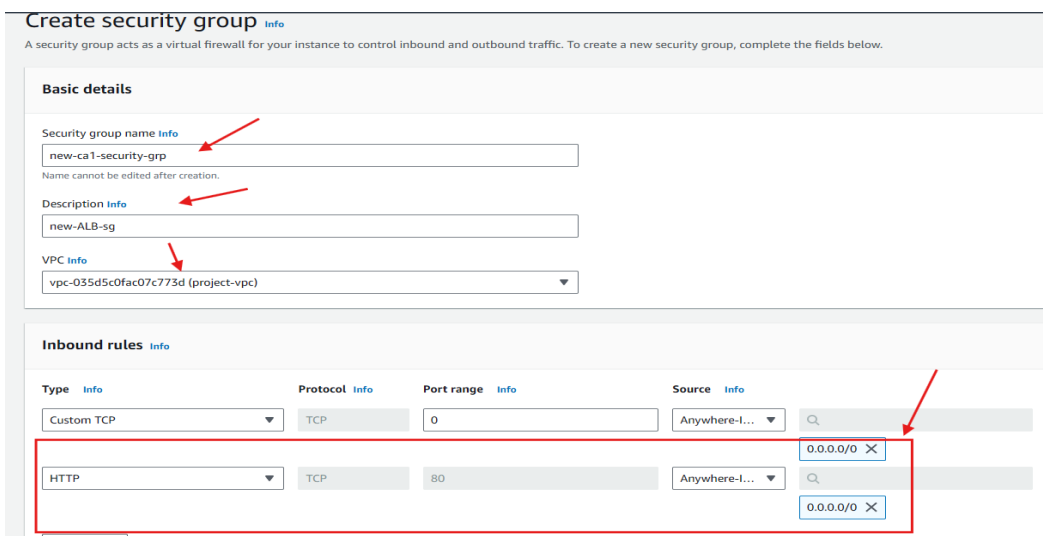
Security group name - required

launch-wizard-6

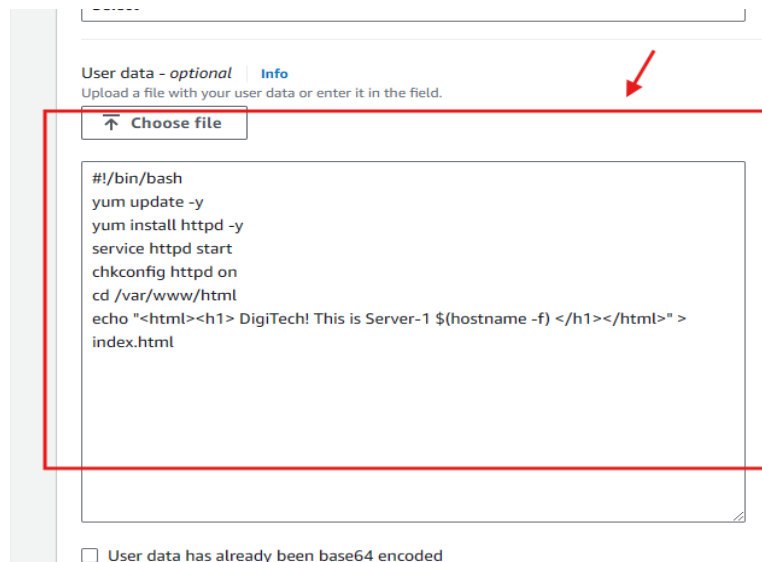
- Create new security group for all Linux servers.



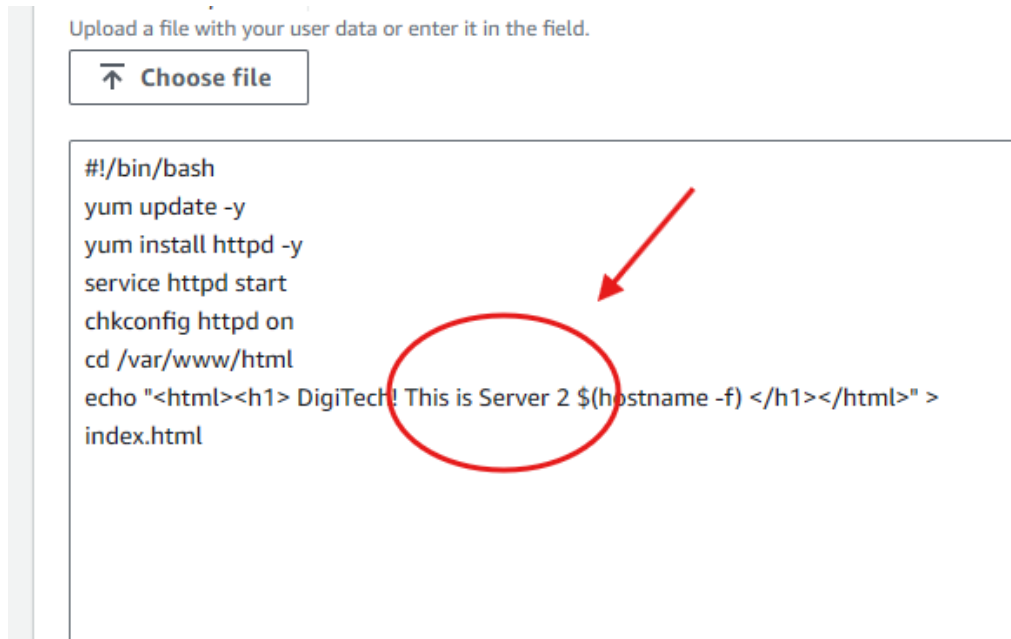
- I gave name with new-ca1-security-grp and description as new-ALB-sg.
- Selected with custom created project-vpc.
- Added inbound rule HTTP.



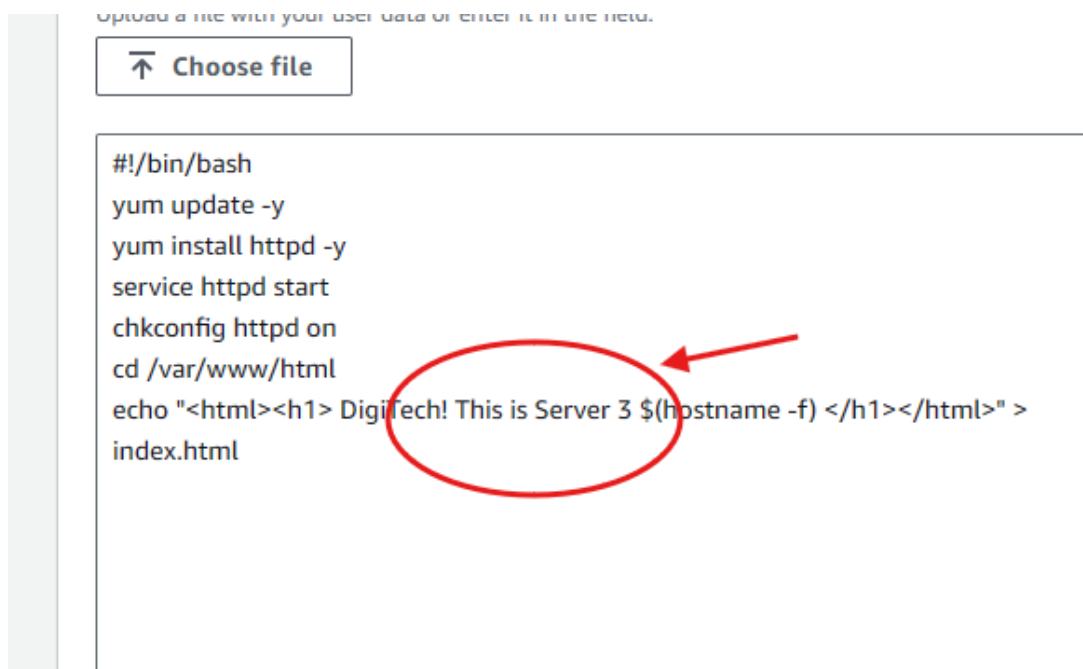
- Gave Linux-startup script in advanced tab for 1st Linux-server and click Launch instance.



- I have created all 5 Linux-servers in same way.
- Gave Linux-startup script in advanced tab for 2nd Linux-server and click Launch instance.




- Gave Linux-startup script in advanced tab for 3rd Linux-server and click Launch instance.



- Gave Linux-startup script in advanced tab for 4th Linux-server and click Launch instance.

```
#!/bin/bash
yum update -y
yum install httpd -y
service httpd start
chkconfig httpd on
cd /var/www/html
echo "<html><h1> DigiTech! This is Server 4 $(hostname -f) </h1></html>" >
index.html
```

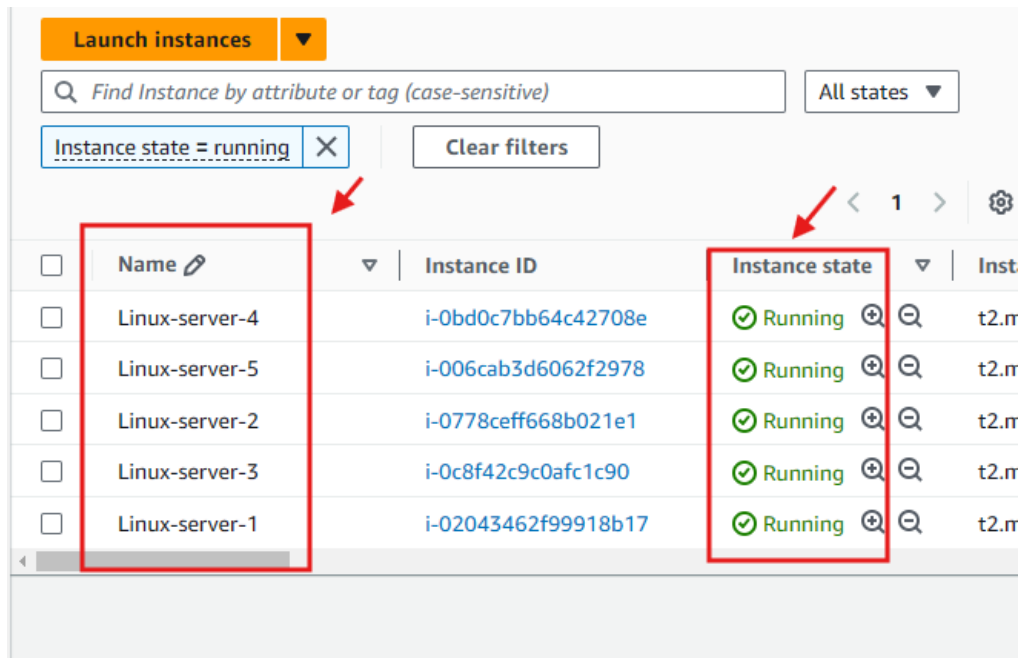


- Gave Linux-startup script in advanced tab for 5th Linux-server and click Launch instance.

```
#!/bin/bash
yum update -y
yum install httpd -y
service httpd start
chkconfig httpd on
cd /var/www/html
echo "<html><h1> DigiTech! This is Server 5 $(hostname -f) </h1></html>" >
index.html
```

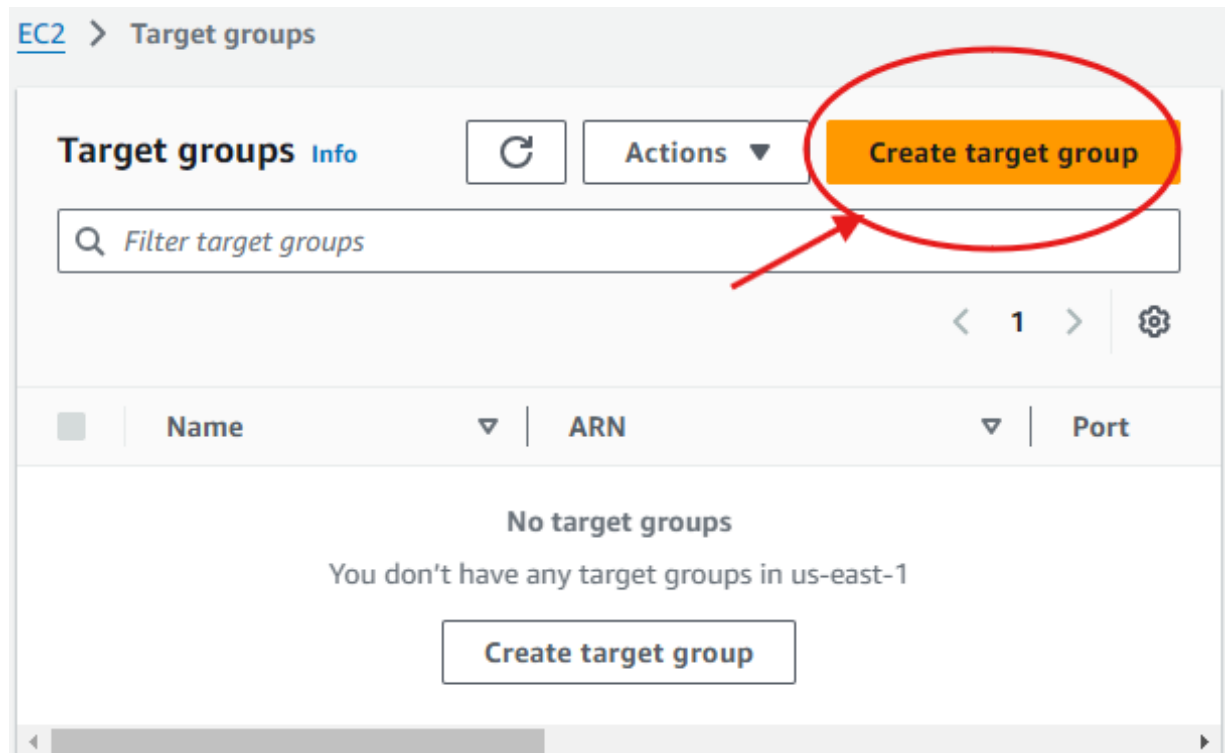


- All 5 Linux-servers has created successfully and can be seen in shot below:



Creation Of Target Group

- Click create target group navigate from left menu in EC2.



- Stick with Instances as target type and gave target group name as Linux-servers-target-group.

Basic configuration
Settings in this section can't be changed after the target group is created.

Choose a target type

☒ **Instances**

- Supports load balancing to instances within a specific VPC.
- Facilitates the use of [Amazon EC2 Auto Scaling](#) to manage and scale your EC2 capacity.

☐ IP addresses

- Supports load balancing to VPC and on-premises resources.
- Facilitates routing to multiple IP addresses and network interfaces on the same instance.
- Offers flexibility with microservice based architectures, simplifying inter-application communication.
- Supports IPv6 targets, enabling end-to-end IPv6 communication, and IPv4-to-IPv6 NAT.

☐ Lambda function

- Facilitates routing to a single Lambda function.
- Accessible to Application Load Balancers only.

☐ Application Load Balancer

- Offers the flexibility for a Network Load Balancer to accept and route TCP requests within a specific VPC.
- Facilitates using static IP addresses and PrivateLink with an Application Load Balancer.

Target group name

Linux-servers-target-group

A maximum of 32 alphanumeric characters including hyphens are allowed, but the name must not begin or end with a hyphen.

Protocol : Port

Choose a protocol for your target group that corresponds to the Load Balancer type that will route traffic to it. Some protocols now include anomaly detection for the targets and you can set mitigation options once your target group is created. This choice cannot be changed after creation

HTTP 80

- Selected custom created project-vpc and Click Next.

IP address type
Only targets with the indicated IP address type can be registered to this target group.

☒ **IPv4**

Each instance has a default network interface (eth0) that is assigned the primary private IPv4 address. The instance's primary private IPv4 address is the one that will be applied to the target.

☐ IPv6

Each instance you register must have an assigned primary IPv6 address. This is configured on the instance's default network interface (eth0). [Learn more](#)

VPC
Select the VPC with the instances that you want to include in the target group. Only VPCs that support the IP address type selected are available in this list.

project-vpc
vpc-035d5c0fac07c773d
IPv4 VPC CIDR: 10.0.0.0/16

Protocol version

☒ **HTTP1**

Send requests to targets using HTTP/1.1. Supported when the request protocol is HTTP/1.1 or HTTP/2.

☐ HTTP2

Send requests to targets using HTTP/2. Supported when the request protocol is HTTP/2 or gRPC, but gRPC-specific features are not available.

☐ gRPC

- Add all 5 Linux-servers in Register targets and click option include pending.

Register targets

This is an optional step to create a target group. However, to ensure that your load balancer routes traffic to this target group you must register your targets.

Available instances (5/5)

<input checked="" type="checkbox"/>	Instance ID	Name
<input checked="" type="checkbox"/>	i-006cab3d6062f2978	Linux-server-5
<input checked="" type="checkbox"/>	i-0bd0c7bb64c42708e	Linux-server-4
<input checked="" type="checkbox"/>	i-0c8f42c9c0afc1c90	Linux-server-3
<input checked="" type="checkbox"/>	i-0778ceff668b021e1	Linux-server-2
<input checked="" type="checkbox"/>	i-02043462f99918b17	Linux-server-1

5 selected

Ports for the selected instances
Ports for routing traffic to the selected instances.

1-65535 (separate multiple ports with commas)

Include as pending below

- All Linux-servers has added and click Create target group.

Review targets

Targets (5)

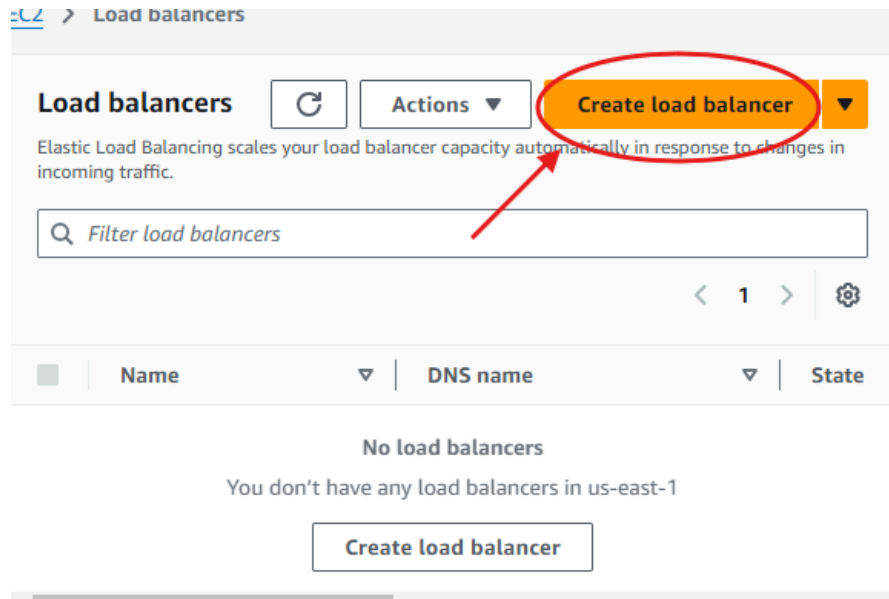
☐ Show only pending

Instance ID	Name	Port	State
i-006cab3d6062f2978	Linux-server-5	80	✓ Running
i-0bd0c7bb64c42708e	Linux-server-4	80	✓ Running
i-0c8f42c9c0afc1c90	Linux-server-3	80	✓ Running
i-0778ceff668b021e1	Linux-server-2	80	✓ Running
i-02043462f99918b17	Linux-server-1	80	✓ Running

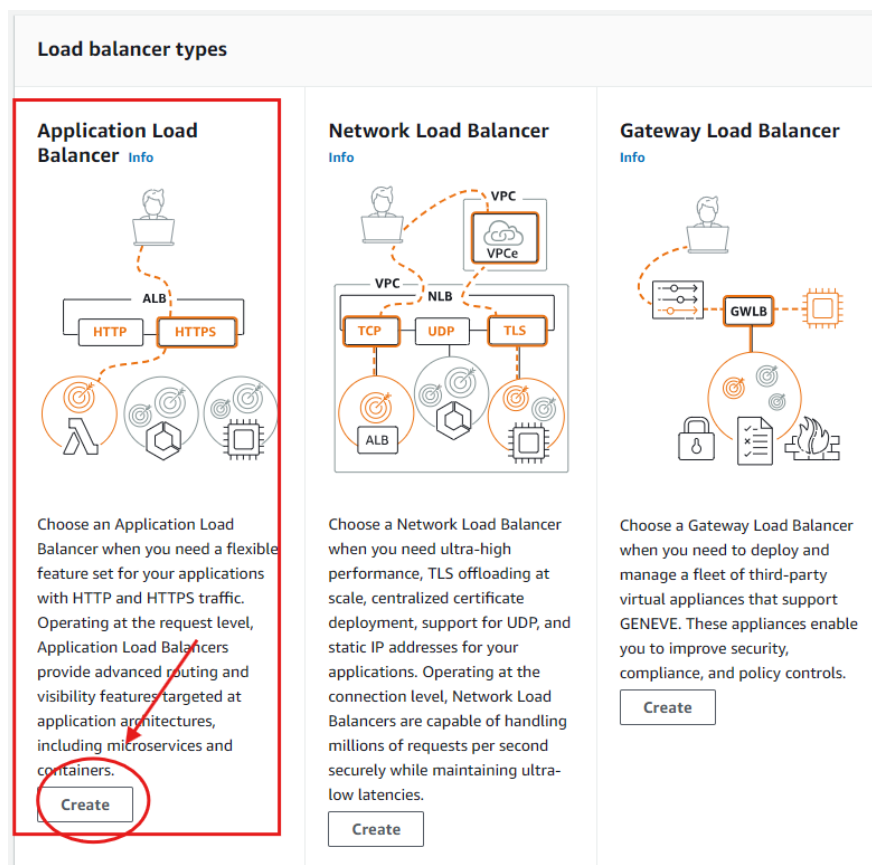
5 pending

Creation of Application Load Balancer (ALB)

- Click create load balancer by navigating from left menu in EC2.



- Selected Application Load Balancer (ALB) and click create.



- Gave name as ca1-2021384-ALB.
- Set internet-facing as Scheme with IPv4 IP address.
- Select custom project-vpc in Network mapping.

Basic configuration

Load balancer name [Info](#)
Name must be unique within your AWS account and can't be changed after the load balancer is created.
Ca1-2021384-ALB
A maximum of 32 alphanumeric characters including hyphens are allowed, but the name must not begin or end with a hyphen.

Scheme [Info](#)
Scheme can't be changed after the load balancer is created.

☒ **Internet-facing**
An internet-facing load balancer routes requests from clients over the internet to targets. Requires a public subnet. [Learn more](#)

☐ **Internal**
An internal load balancer routes requests from clients to targets using private IP addresses. Compatible with the IPv4 and IPv6 address types.

Load balancer IP address type [Info](#)
Select the front-end IP address type to assign to the load balancer. The VPC and subnets mapped to this load balancer must include an additional cost.

☒ **IPv4**
Includes only IPv4 addresses.

☐ **Dualstack**
Includes IPv4 and IPv6 addresses.

☐ **Dualstack without public IPv4**
Includes a public IPv6 address, and private IPv4 and IPv6 addresses. Compatible with internet-facing load balancers only.

Network mapping [Info](#)
The load balancer routes traffic to targets in the selected subnets, and in accordance with your IP address settings.

VPC [Info](#)
The load balancer will exist and scale within the selected VPC. The selected VPC is also where the load balancer targets must be using VPC peering. To confirm the VPC for your targets, view [target groups](#). For a new VPC, [create a VPC](#).

project-vpc
vpc-035d5c0fac07c773d
IPv4 VPC CIDR: 10.0.0.0/16

Mappings [Info](#)

- Selected both public subnets in both Availability Zones.

Network mapping [Info](#)
The load balancer routes traffic to targets in the selected subnets, and in accordance with your IP address settings.

VPC [Info](#)
The load balancer will exist and scale within the selected VPC. The selected VPC is also where the load balancer targets must be hosted unless routing to Lambda using VPC peering. To confirm the VPC for your targets, view [target groups](#). For a new VPC, [create a VPC](#).

project-vpc
vpc-035d5c0fac07c773d
IPv4 VPC CIDR: 10.0.0.0/16

Mappings [Info](#)
Select at least two Availability Zones and one subnet per zone. The load balancer routes traffic to targets in these Availability Zones only. Availability Zones that are not available for selection.

Availability Zones

☒ **us-east-1a (use1-az6)**

Subnet
subnet-0e53f96720c57915f
IPv4 subnet CIDR: 10.0.0.0/20
project-subnet-public1-us-east-1a

IPv4 address
Assigned by AWS

☒ **us-east-1b (use1-az1)**

Subnet
subnet-0951835d1260e7ca4
IPv4 subnet CIDR: 10.0.16.0/20
project-subnet-public2-us-east-1b

IPv4 address
Assigned by AWS

- Selected custom created new-ca1-security-grp for security group and newly created target group Linux-servers-target-group for listeners from HTTP port 80.

Security groups [Info](#)

A security group is a set of firewall rules that control the traffic to your load balancer. Select an existing security group, or you can [create a new security group](#).

Security groups

Select up to 5 security groups

new-ca1-security-grp
sg-0ec4c4437dad3f1e3 VPC: vpc-035d5c0fac07c773d

Listeners and routing [Info](#)

A listener is a process that checks for connection requests using the port and protocol you configure. The rules that you define for a listener determine how the load balancer routes requests to its registered targets.

▼ Listener HTTP:80

Remove

Protocol

HTTP

Port

80

1-65535

Default action

[Info](#)

Forward to

Linux-servers-target-group

Target type: Instance, IPv4

HTTP

[Create target group](#)

Listener tags - optional

- Ca1-2021384-ALB application load balancer has created successfully.

Load balancers (1)							
Elastic Load Balancing scales your load balancer capacity automatically in response to changes in incoming traffic.							
Filter load balancers							
<input type="checkbox"/>	Name	DNS name	State	VPC ID	Availability Zones	Type	Date created
<input type="checkbox"/>	Ca1-2021384-ALB	Ca1-2021384-ALB-19273...	Provisioning...	vpc-035d5c0fac07c773d	2 Availability Zones	application	November 4, 2024, 01:37 (UTC+00:00)

- Now, Go inside the ALB and copy the DNS name of Ca1-2021384-ALB and search in browser.

▼ Details

Load balancer type

Application

Scheme

Internet-facing

VPC

[vpc-035d5c0fac07c773d](#)

Availability Zones

[subnet-0951835d1260e7ca4](#) us-east-1b (use1-az1)
[subnet-0e53f96720c57915f](#) us-east-1a (use1-az6)

Load balancer ARN

arn:aws:elasticloadbalancing:us-east-1:199428924135:loadbalancer/app/Ca1-2021384-ALB/6e779dd6bfdbea67

Status

Provisioning

Hosted zone

Z35SXDOTRQ7X7K

Load balancer IP address type

IPv4

Date created

November 4, 2024, 01:37 (UTC+00:00)

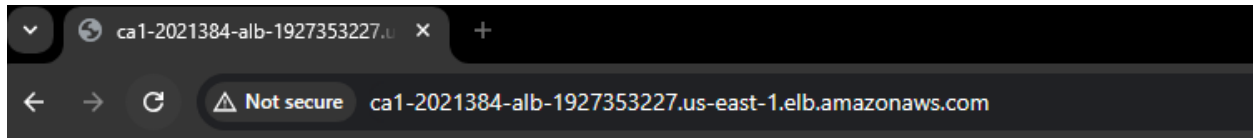
Ca1-2021384-ALB-1927353227.us-east-1.elb.amazonaws.com (A Record)

Listeners and rules

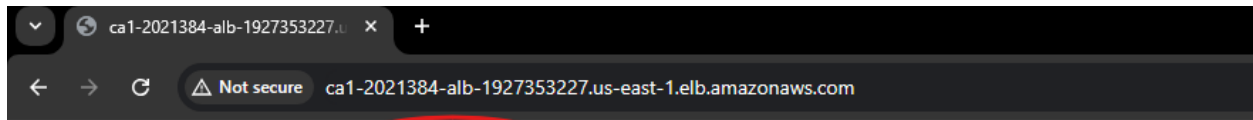
Network mapping

Resource map - new

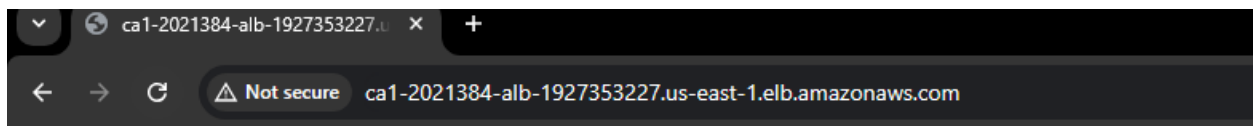
- It can be seen in the screen shots below the Application Load Balancer (ALB) is working properly by reloading the page again and again it showing different servers with the same DNS name URL in browser.



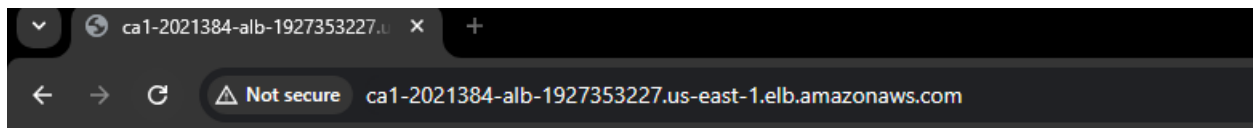
DigiTech! This is Server 1ip-10-0-156-15.ec2.internal



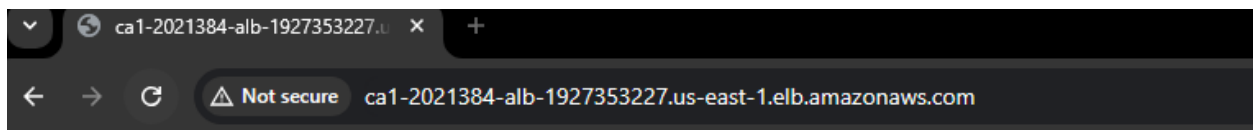
DigiTech! This is Server 5ip-10-0-148-171.ec2.internal



DigiTech! This is Server 3ip-10-0-155-37.ec2.internal



DigiTech! This is Server 4ip-10-0-152-145.ec2.internal



DigiTech! This is Server 2ip-10-0-145-102.ec2.internal

Q2(b): Challenge Task: Incorporate the DigiTech Website with ALB

- Go inside each server one by one and connect them using EC2 instance connect for uploading the DigiTech website and configuration.

Connect to instance [Info](#)

Connect to your instance i-014332f98885c98d7 (Linux-server-1) using any of these options

EC2 Instance Connect | Session Manager | SSH client | EC2 serial console

Port 22 (SSH) is open to all IPv4 addresses
Port 22 (SSH) is currently open to all IPv4 addresses, indicated by **0.0.0.0/0** in the inbound rule in [your security group](#). For increased security, consider restricting access to only the EC2 Instance Connect service IP addresses for your Region: 18.206.107.24/29. [Learn more](#).

Instance ID
☒ i-014332f98885c98d7 (Linux-server-1)

Connection Type

☒ **Connect using EC2 Instance Connect**
Connect using the EC2 Instance Connect browser-based client, with a public IPv4 or IPv6 address.

☐ **Connect using EC2 Instance Connect Endpoint**
Connect using the EC2 Instance Connect browser-based client, with a private IPv4 address and a VPC endpoint.

☒ **Public IPv4 address**
☒ 54.211.134.198

☐ **IPv6 address**
-

Username
Enter the username defined in the AMI used to launch the instance. If you didn't define a custom username, use the default username, ec2-user.

Note: In most cases, the default username, ec2-user, is correct. However, read your AMI usage instructions to check if the AMI owner has changed the default AMI username.

[Cancel](#) [Connect](#)

- Uploaded DigiTech web content inside each server from local machine by using pscp command in command prompt with the .ppk key which used for each server.
- By using this method I uploaded DigiTech website in each machine's home by using /home/ec2-user/ at the end of pscp command.
- Then, move all files from /home/ec2-user/ directory to /var/www/html/ directory by using sudo mv command.
- Removed default Apache html page by using sudo rm command from /var/www/html/ directory.
- Configure the httpd page with sudo nano.


```

Amazon Linux 2023
https://aws.amazon.com/linux/amazon-linux-2023

last login: Wed Nov 13 03:37:18 2024 from 18.206.107.29
[ec2-user@ip-10-0-3-208 ~]$ ls /home/ec2-user/
[ec2-user@ip-10-0-3-208 ~]$ ls /home/ec2-user/
MotorTax ftp_content desktop.ini images index.htm
[ec2-user@ip-10-0-3-208 ~]$ sudo mv /home/ec2-user/* /var/www/html/
[ec2-user@ip-10-0-3-208 ~]$ ls /var/www/html/
MotorTax ftp_content desktop.ini images index.htm index.html
[ec2-user@ip-10-0-3-208 ~]$ sudo rm /var/www/html/index.html
[ec2-user@ip-10-0-3-208 ~]$ sudo nano /etc/httpd/conf/httpd.conf

```

```

C:\Users\PC\pscp -i "C:\Users\PC\Documents\Year4-2024-384-key.ppk" -r "C:\Users\PC\Downloads\Digitech_website\*" ec2-use
r@54.211.134.198:/home/ec2-user/
The host key is not cached for this server:
 54.211.134.198 (port 22)
You have no guarantee that the server is the computer you
think it is.
The server's ssh-ed25519 key fingerprint is:
ssh-ed25519 255 SHA256:f2Z4H4eM02dmRyfwXnTyYTN9Uj+oVD6D1McoJcoBZoo
If you trust this host, enter "y" to add the key to PSCP's
cache and carry on connecting.
If you want to carry on connecting just once, without adding
the key to the cache, enter "n".
If you do not trust this host, press Return to abandon the
connection.
Store key in cache? (y/n, Return cancels connection, i for more info) y
desktop.ini      0 kB | 0.1 kB/s | ETA: 00:00:00 | 100%
construction (1).jpg 11 kB | 11.0 kB/s | ETA: 00:00:00 | 100%
construction.jpg   11 kB | 11.0 kB/s | ETA: 00:00:00 | 100%
construction2.jpg  14 kB | 15.0 kB/s | ETA: 00:00:00 | 100%
desktop.ini       0 kB | 0.1 kB/s | ETA: 00:00:00 | 100%
digitech (1).jpg  14 kB | 14.6 kB/s | ETA: 00:00:00 | 100%
digitech.jpg      14 kB | 14.6 kB/s | ETA: 00:00:00 | 100%
digitech_create (1).jpg 4 kB | 4.2 kB/s | ETA: 00:00:00 | 100%
digitech_create.jpg 4 kB | 4.2 kB/s | ETA: 00:00:00 | 100%
index.htm         1 kB | 1.3 kB/s | ETA: 00:00:00 | 100%
CHANGE OF PARTICULARS.pdf 156 kB | 156.7 kB/s | ETA: 00:00:00 | 100%
desktop.ini       0 kB | 0.1 kB/s | ETA: 00:00:00 | 100%
MOTOR TAX RENEWAL FORM.pdf 375 kB | 375.3 kB/s | ETA: 00:00:00 | 100%
TRANSFER OF OWNERSHIP.pdf 119 kB | 119.7 kB/s | ETA: 00:00:00 | 100%

```

- Set DirectoryIndex inside the httpd file for giving priority to Digitech html file first while displaying and save file by ctrl x.
- Run command sudo systemctl restart httpd for restarting.

```

GNU nano 5.8
<IfModule mime_magic_module>
#
# The mod_mime_magic module allows the server to use various hints
# contents of the file itself to determine its type. The MIMEMagicFile
# directive tells the module where the hint definitions are located
#
MIMEMagicFile conf/magic
</IfModule>

#
# Customizable error responses come in three flavors:
# 1) plain text 2) local redirects 3) external redirects
#
# Some examples:
#ErrorDocument 500 "The server made a boo boo."
#ErrorDocument 404 /missing.html
#ErrorDocument 404 "/cgi-bin/missing_handler.pl"
#ErrorDocument 402 http://www.example.com/subscription_info.html
#

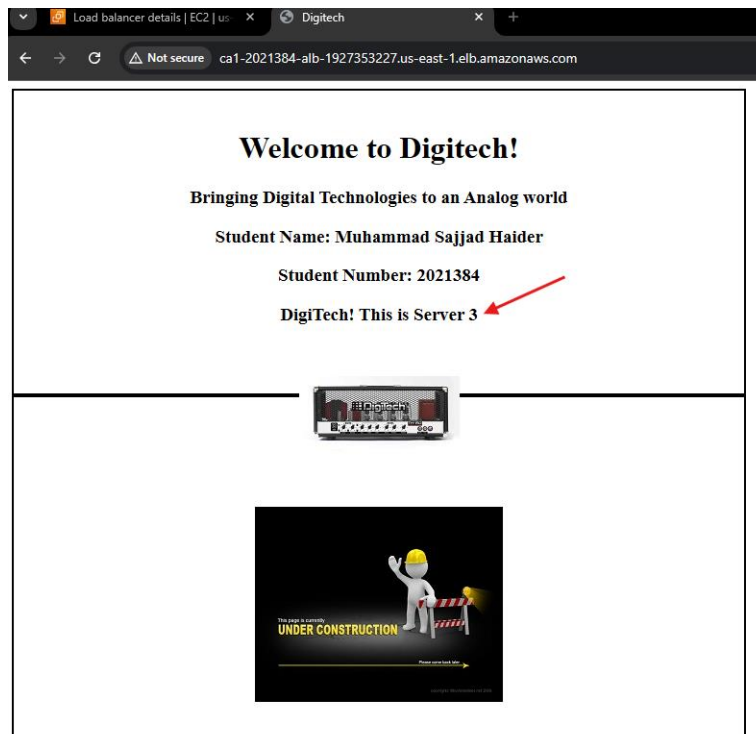
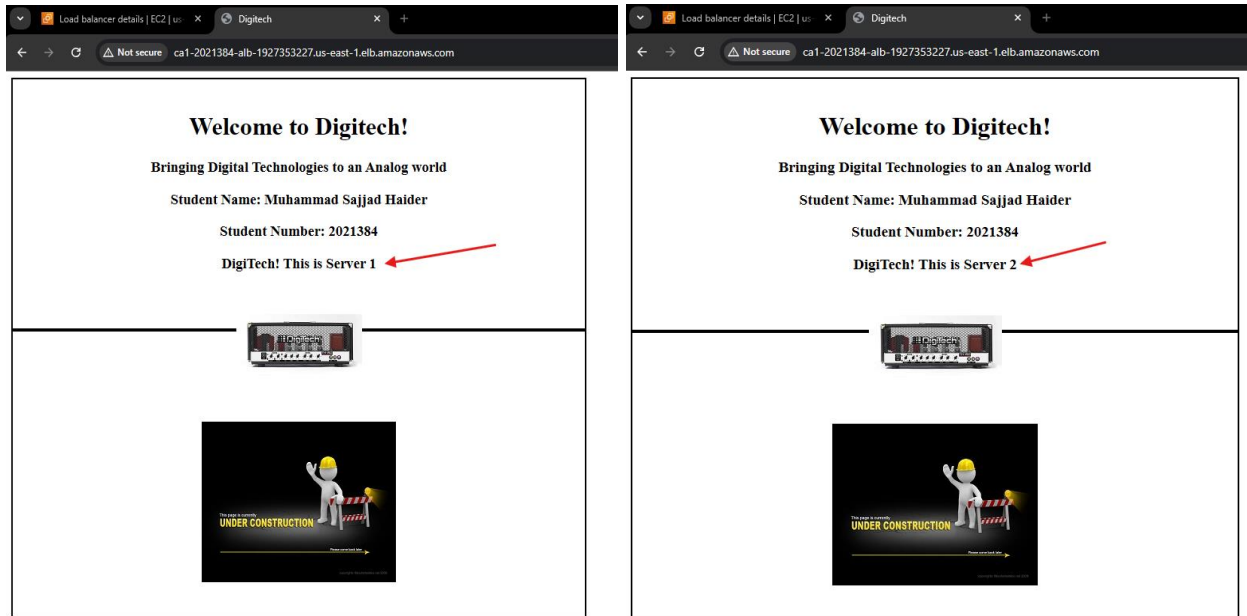
#
# EnableMMAP and EnableSendfile: On systems that support it,
# memory-mapping or the sendfile syscall may be used to deliver
# files. This usually improves server performance, but must
# be turned off when serving from networked-mounted
# filesystems or if support for these functions is otherwise
# broken on your system.
# Defaults if commented: EnableMMAP On, EnableSendfile Off
#
#EnableMMAP off
EnableSendfile on

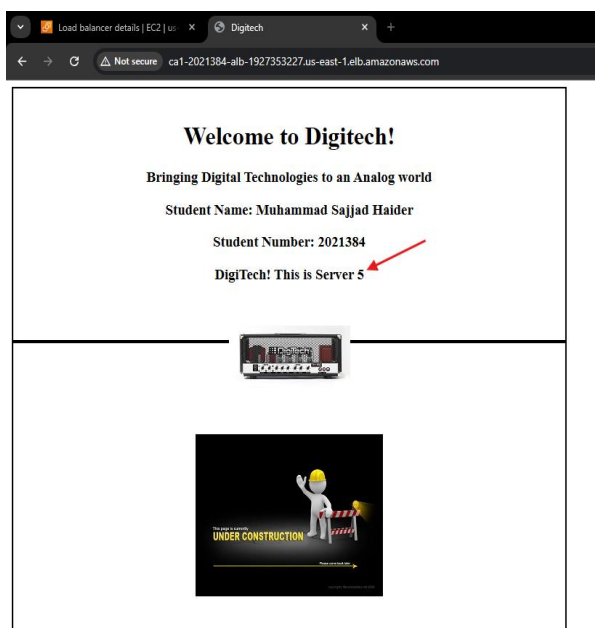
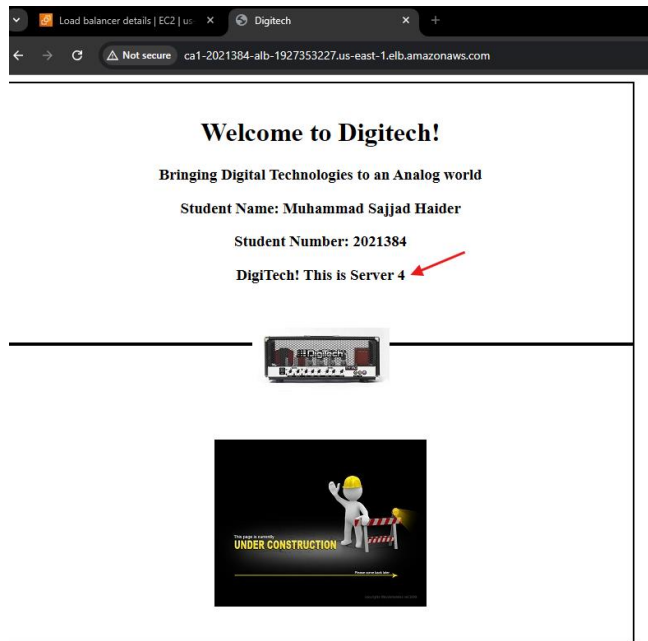
# Supplemental configuration
#
# Load config files in the "/etc/httpd/conf.d" directory, if any.
IncludeOptional conf.d/*.conf
DirectoryIndex index.htm index.html

```

i-014332f98885c98d7 (Linux-server-1)

- After configuring each Linux-server instance.
- Go inside Application Load Balancer (ALB).
- Copy DNS name and search in browser.
- It can be seen the Digitech webpage is displaying with different server names by applying ALB.

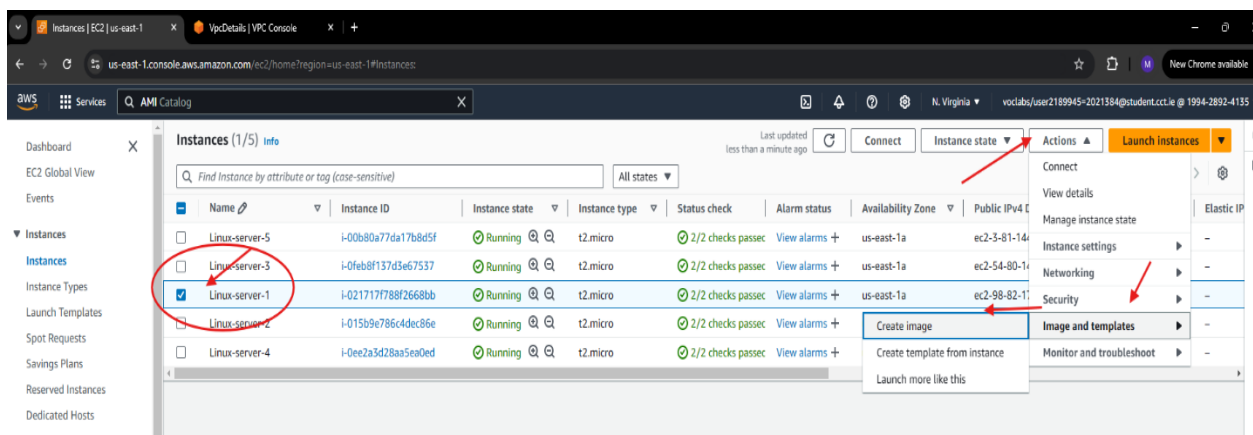




Q3(a): Challenge Task: Proof Of concept, Auto Scaling Group with ALB

Creation AMI image:

- Firstly, I created AMI image from Digitech website hosting Linux-server-1 for corporation with Clouds-Are-Us.
- Select Linux-server-1, click Actions.
- Go to Image and templates and click Create Image.



- Set Image name as Digitech-to-ASG-image.
- Click Create.

[EC2](#) > [Instances](#) > [i-021717f788f2668bb](#) > Create image

Create image [Info](#)

An image (also referred to as an AMI) defines the programs and settings that are applied when you launch an EC2 instance. You can create an image from configuration of an existing instance.

Instance ID
i-021717f788f2668bb (Linux-server-1)

Image name
Digitech-to-ASG-image
Maximum 127 characters. Can't be modified after creation.

Image description - optional
Digitech-to-ASG-image
Maximum 255 characters

☒ Reboot instance
When selected, Amazon EC2 reboots the instance so that data is at rest when snapshots of the attached volumes are taken. This ensures data consistency.

Instance volumes

- Navigate AMIs in EC2, it can be seen the Digtect-to-ASG-image has created.

Amazon Machine Images (AMIs) (1) [Info](#)

Owned by me

[Recycle Bin](#) [EC2 Image Builder](#) [Actions](#) [Launch](#)

<input type="checkbox"/>	Name ↗	AMI name	AMI ID	Source	Owner	Visibility	Status
<input type="checkbox"/>		Digtect-to-ASG-image	ami-023949f9471f30ed7	199428924135/Digtect-to-ASG-image	199428924135	Private	Available 🔍

Target group for ASG:

- Set Target group name as ASG-Target-grp-384.
- HTTP protocol with port 80 and IPv4 as IP address type.
- Attached custom created VPC project-vpc.
- Click Create.

Target group name

ASG-Target-grp-384

A maximum of 32 alphanumeric characters including hyphens are allowed, but the name must not begin or end with a hyphen.

Protocol : Port

Choose a protocol for your target group that corresponds to the Load Balancer type that will route traffic to it. Some protocols now include anomaly detection for the targets and you can set mitigation options once your target group is created. This choice cannot be changed after creation

HTTP 80

1-65535

IP address type

Only targets with the indicated IP address type can be registered to this target group.

☒ IPv4

Each instance has a default network interface (eth0) that is assigned the primary private IPv4 address. The instance's primary private IPv4 address is the one that will be applied to the target.

☐ IPv6

Each instance you register must have an assigned primary IPv6 address. This is configured on the instance's default network interface (eth0). [Learn more](#)

VPC

Select the VPC with the instances that you want to include in the target group. Only VPCs that support the IP address type selected above are available in this list.

project-vpc

vpc-035d5c0fac07c773d

IPv4 VPC CIDR: 10.0.0.0/16

- Updated ALB, Attach ASG-Target-grp-384 with forward routing actions at HTTP port 80 in Listener details.

Listener details

A listener checks for connection requests using the protocol and port that you configure. The default action and any additional actions you create determine how the Application Load Balancer routes requests to its registered targets.

Listener ARN
`arn:aws:elasticloadbalancing:us-east-1:199428924135:listener/app/Ca1-2021384-ALB/6e779dd6bdfdb4c99100e1`

Listener configuration

The listener will be identified by the protocol and port.

Protocol
Used for connections from clients to the load balancer.
HTTP

Port
The port on which the load balancer is listening for connections.
80

Default actions | Info
The default action is used if no other rules apply. Choose the default action for traffic on this listener.

Routing actions

☒ Forward to target groups ☐ Redirect to URL ☐ Return fixed response

Forward to target group | Info
Choose a target group and specify routing weight, or [Create target group](#).

Target group	Protocol	Weight	Percent
ASG-Target-grp-384 Target type: Instance, IPv4	HTTP	1	100%

[Add target group](#)

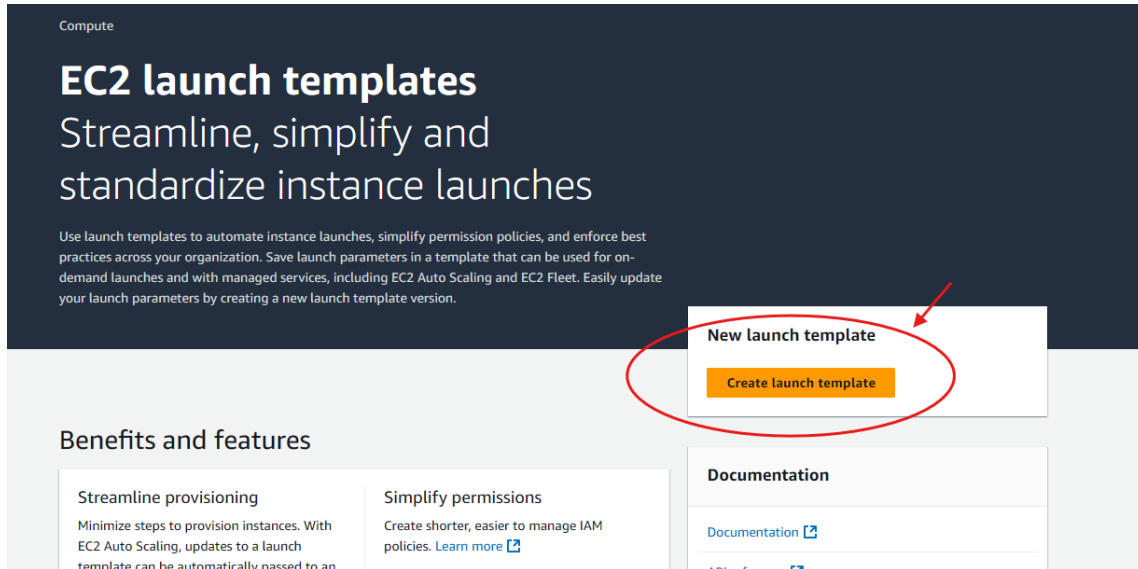
You can add up to 4 more target groups.

Target group stickiness | Info
Enables the load balancer to bind a user's session to a specific target group. To use stickiness the client must support cookies. To bind a user's session to a specific target, turn on the Target Group attribute Stickiness.

☐ Turn on target group stickiness

Creation of Launch Template:

- Navigate Launch Template inside EC2.
- Create Launch Template for Auto scaling group (ASG).



- Gave template name as ASG-Template-384.
- Set version 1 and set tag value as my-ASG-template-384.

Create launch template

Creating a launch template allows you to create a saved instance configuration that can be reused, shared and updated at a later time. Templates can have multiple versions.

Launch template name and description

Launch template name - required

ASG-Template-384

Must be unique to this account. Max 128 chars. No spaces or special characters like '&', '*', '@'.

Template version description

Version 1

Max 255 chars

Auto Scaling guidance [Info](#)

Select this if you intend to use this template with EC2 Auto Scaling

☐ Provide guidance to help me set up a template that I can use with EC2 Auto Scaling

▼ Template tags

Key	Info	Value	Info
Name		my-ASG-template-384	

Use: my-ASG-template-384

[Add new tag](#)

You can add up to 49 more tags.

[► Source template](#)

- Attached Digitect-to-ASG-image as Amazon Machine Image (AMI) , which is created for corporation with Clouds-Are-Us.

Launch template contents
Specify the details of your launch template below. Leaving a field blank will result in the field not being included in the launch template.

▼ **Application and OS Images (Amazon Machine Image) - required** [Info](#)

An AMI is a template that contains the software configuration (operating system, application server, and applications) required to launch your instance. Search or Browse for AMIs if you don't see what you are looking for below

Q Search our full catalog including 1000s of application and OS images

Recents **My AMIs** Quick Start

☒ Owned by me ☐ Shared with me

[Browse more AMIs](#)
Including AMIs from AWS, Marketplace and the Community

Amazon Machine Image (AMI)

Digitect-to-ASG-image
ami-023949f9471f30ed7
2024-11-16T01:21:45.000Z Virtualization: hvm ENA enabled: true Root device type: ebs

Description
Digitect-to-ASG-image

Architecture	AMI ID
x86_64	ami-023949f9471f30ed7

- Stick with Year4-2024-384-key and existing new-ca1-security-grp.

▼ **Key pair (login)** [Info](#)

You can use a key pair to securely connect to your instance. Ensure that you have access to the selected key pair before you launch the instance.

Key pair name
Year4-2024-384-key [Create new key](#)

▼ **Network settings** [Info](#)

Subnet [Info](#)
Don't include in launch template [Create new subnet](#)
When you specify a subnet, a network interface is automatically added to your template.

Firewall (security groups) [Info](#)
A security group is a set of firewall rules that control the traffic for your instance. Add rules to allow specific traffic to reach your instance.

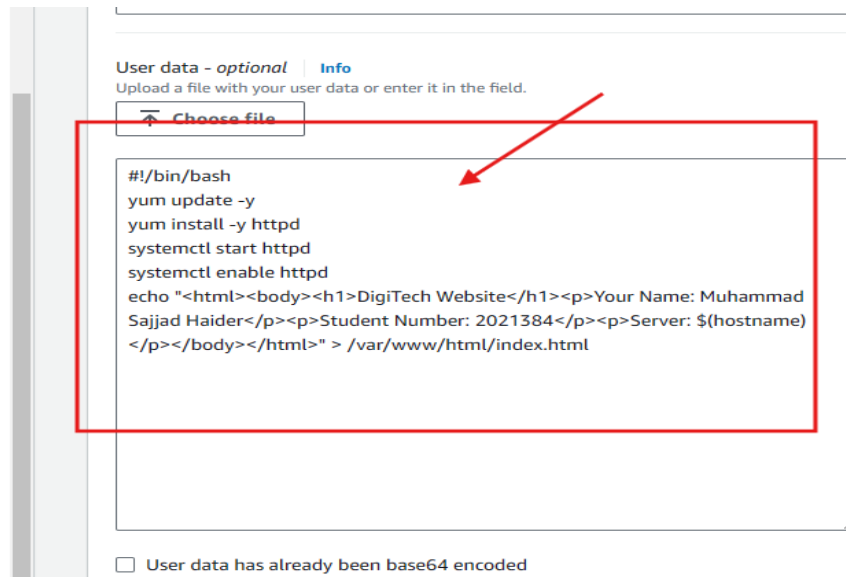
☒ Select existing security group ☐ Create security group

Security groups [Info](#)
Select security groups

new-ca1-security-grp sg-0ec4c4437dad3f1e3 X
VPC: vpc-035d5c0fac07c773d [Compare security group rules](#)

► Advanced network configuration

- Simple User data script for Launch Template.



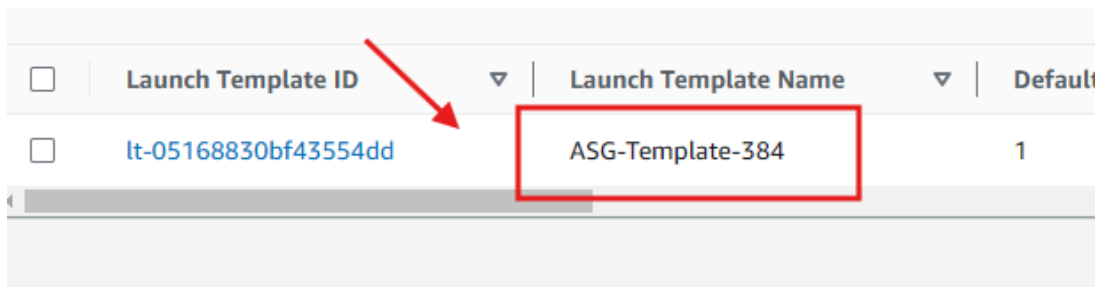
User data - optional [Info](#)
Upload a file with your user data or enter it in the field.

[Choose file](#)

```
#!/bin/bash
yum update -y
yum install -y httpd
systemctl start httpd
systemctl enable httpd
echo "<html><body><h1>DigiTech Website</h1><p>Your Name: Muhammad Sajjad Haider</p><p>Student Number: 2021384</p><p>Server: $(hostname) </p></body></html>" > /var/www/html/index.html
```

☐ User data has already been base64 encoded

- ASG-Template-384 has successfully created.



<input type="checkbox"/>	Launch Template ID	Launch Template Name	Default
<input type="checkbox"/>	lt-05168830bf43554dd	ASG-Template-384	1

Creation of ASG with attached ALB:

- Navigate Auto scaling group (ASG) in EC2 and Click create Auto Scaling Group.

automatic scaling and fleet management features. These features help you maintain the health and availability of your applications.

Create Auto Scaling group

Get started with EC2 Auto Scaling by creating an Auto Scaling group.

[Create Auto Scaling group](#)

- Set name as ASG-alb-2021384 and attached ASG-Template-384 custom created with version 1.

Name

Auto Scaling group name
Enter a name to identify the group.

ASG-alb-2021384

Must be unique to this account in the current Region and no more than 255 characters.

Launch template [Info](#)

Launch template
Choose a launch template that contains the instance-level settings, such as the Amazon Machine Image (AMI), instance type, key pair, and security groups.

ASG-Template-384

[Create a launch template](#)

Version

1

- In Network, Attached custom created project-vpc.
- Attached private subnets only of both Availability Zones and hit Next.

Network [Info](#)

For most applications, you can use multiple Availability Zones and let EC2 Auto Scaling balance your instances across the zones. The default VPC and default subnets are suitable for getting started quickly.

VPC
Choose the VPC that defines the virtual network for your Auto Scaling group.

vpc-035d5c0fac07c773d (project-vpc)
10.0.0.0/16

[Create a VPC](#)

Availability Zones and subnets
Define which Availability Zones and subnets your Auto Scaling group can use in the chosen VPC.

Select Availability Zones and subnets

us-east-1a | subnet-043596075018cd322 (project-subnet-private1-us-east-1a)
10.0.128.0/20

us-east-1b | subnet-0f0d22e6b14f2b4bd (project-subnet-private2-us-east-1b)
10.0.144.0/20

[Create a subnet](#)

Availability Zone distribution - new
Auto Scaling automatically balances instances across Availability Zones. If launch failures occur in a zone, select a strategy.

☒ **Balanced best effort**
If launches fail in one Availability Zone, Auto Scaling will attempt to launch in another healthy Availability Zone.

☐ **Balanced only**
If launches fail in one Availability Zone, Auto Scaling will continue to attempt to launch in the unhealthy Availability Zone to preserve balanced distribution.

Cancel Skip to review Previous **Next**

- Attach Existed Application Load Balancer (ALB) from ASG-Target-grp-384 of load balancer which configured above.

Load balancing [Info](#)

Use the options below to attach your Auto Scaling group to an existing load balancer, or to a new load balancer that you define.

☐ **No load balancer**
Traffic to your Auto Scaling group will not be fronted by a load balancer.

☒ **Attach to an existing load balancer**
Choose from your existing load balancers.

☐ **Attach to a new load balancer**
Quickly create a basic load balancer to attach to your Auto Scaling group.

Attach to an existing load balancer
Select the load balancers that you want to attach to your Auto Scaling group.

☒ **Choose from your load balancer target groups**
This option allows you to attach Application, Network, or Gateway Load Balancers.

☐ **Choose from Classic Load Balancers**

Existing load balancer target groups
Only instance target groups that belong to the same VPC as your Auto Scaling group are available for selection.

Select target groups

ASG-Target-grp-384 | HTTP
Application Load Balancer: Ca1-2021384-ALB

- Set desired capacity at 3 and scaling limits min max desired capacities at 2 and 5, respectively.

Desired capacity
Specify your group size.

3

Scaling [Info](#)

You can resize your Auto Scaling group manually or automatically to meet changes in demand.

Scaling limits
Set limits on how much your desired capacity can be increased or decreased.

Min desired capacity
2
Equal or less than desired capacity

Max desired capacity
5
Equal or greater than desired capacity

Automatic scaling - optional
Choose whether to use a target tracking policy | [Info](#)
You can set up other metric-based scaling policies and scheduled scaling after creating your Auto Scaling group.

☐ **No scaling policies**
Your Auto Scaling group will remain at its initial size and will not dynamically resize to meet demand.

☒ **Target tracking scaling policy**
Choose a CloudWatch metric and target value; the scaling policy adjusts the desired capacity to the metric's value.

Scaling policy name
Target Tracking Policy

Metric type | [Info](#)
Monitored metric that determines if resource utilization is too low or high. If using EC2 metrics, consider enabling detailed monitoring for better scaling performance.

Average CPU utilization

Target value
30

- Set Health Checks with Elastic Load Balancing.

Health checks

Health checks increase availability by replacing unhealthy instances. When you use multiple health checks, all are evaluated, and if at least one fails, instance replacement occurs.

EC2 health checks

[Always enabled](#)

Additional health check types - optional [Info](#)

☒ **Turn on Elastic Load Balancing health checks** Recommended

Elastic Load Balancing monitors whether instances are available to handle requests. When it reports an unhealthy instance, EC2 Auto Scaling can replace it on its next periodic check.

EC2 Auto Scaling will start to detect and act on health checks performed by Elastic Load Balancing. To avoid unexpected terminations, first verify the settings of these health checks in the [Load Balancer console](#).

☐ Turn on VPC Lattice health checks

VPC Lattice can monitor whether instances are available to handle requests. If it considers a target as failed a health check, EC2 Auto Scaling replaces it after its next periodic check.

☐ Turn on Amazon EBS health checks

EBS monitors whether an instance's root volume or attached volume stalls. When it reports an unhealthy volume, EC2 Auto Scaling can replace the instance on its next periodic health check.

Health check grace period [Info](#)

This time period delays the first health check until your instances finish initializing. It doesn't prevent an instance from terminating when placed into a non-running state.

300 seconds

- Add Tags Value as ASG-ALB-instances.

Add tags - optional [Info](#)

Add tags to help you search, filter, and track your Auto Scaling group across AWS. You can also choose to automatically add these tags to instances when they are launched.

You can optionally choose to add tags to instances (and their attached EBS volumes) by specifying tags in your launch template. We recommend caution, however, because the tag values for instances from your launch template will be overridden if there are any duplicate keys specified for the Auto Scaling group.

Tags (1)

Key	Value - optional	Tag new instances	
Name	ASG-ALB-instances	<input checked="" type="checkbox"/>	Remove

[Add tag](#)

49 remaining

Cancel Previous **Next**

- ASG-alb-2021384 auto scaling group has created successfully.

Auto Scaling groups (1) [Info](#)

[Launch configurations](#) [Launch templates](#) [Actions](#) [Create Auto Scaling group](#)

Search your Auto Scaling groups

Name	Launch template/configuration	Instances	Status	Desired capacity	Min	Max	Availability Zones
ASG-alb-2021384	ASG-Template-384 Version 1	3	-	3	2	5	us-east-1a, us-east-1b

- ASG-ALB-instances are appeared and running successfully.

Instances (3/8) Info Last updated less than a minute ago

Find Instance by attribute or tag (case-sensitive) All states ▼

<input type="checkbox"/>	Name	Instance ID	Instance state	Instance type	Status check	Alarm s
<input type="checkbox"/>	Linux-server-3	i-0fa21b07b6059d536	Running	t2.micro	2/2 checks passed	View al
<input type="checkbox"/>	Linux-server-5	i-065447aadf3e06434	Running	t2.micro	2/2 checks passed	View al
<input type="checkbox"/>	Linux-server-4	i-060ad253c77692ae2	Running	t2.micro	2/2 checks passed	View al
<input type="checkbox"/>	Linux-server-2	i-0ae26dadd7d37ad25	Running	t2.micro	2/2 checks passed	View al
<input checked="" type="checkbox"/>	ASG-ALB-instances	i-0e67ed1740ca0cf58	Running	t2.micro	2/2 checks passed	View al
<input checked="" type="checkbox"/>	ASG-ALB-instances	i-03c987f687b8eb596	Running	t2.micro	2/2 checks passed	View al
<input type="checkbox"/>	Linux-server-1	i-03fb460939a7ae5e1	Running	t2.micro	2/2 checks passed	View al
<input checked="" type="checkbox"/>	ASG-ALB-instances	i-01a362eeb2c7d81ce	Running	t2.micro	2/2 checks passed	View al

- It can be seen that ASG-ALB-instances are coming again and again after termination.

Instances (10) Info Last updated less than a minute ago

Find Instance by attribute or tag (case-sensitive) All states ▼

<input type="checkbox"/>	Name	Instance ID	Instance state	Instance type	Status check	Al
<input type="checkbox"/>	Linux-server-3	i-0fa21b07b6059d536	Running	t2.micro	2/2 checks passed	Vi
<input type="checkbox"/>	Linux-server-5	i-065447aadf3e06434	Running	t2.micro	2/2 checks passed	Vi
<input type="checkbox"/>	Linux-server-4	i-060ad253c77692ae2	Running	t2.micro	2/2 checks passed	Vi
<input type="checkbox"/>	Linux-server-2	i-0ae26dadd7d37ad25	Running	t2.micro	2/2 checks passed	Vi
<input type="checkbox"/>	ASG-ALB-instances	i-0e67ed1740ca0cf58	Terminated	t2.micro	-	Vi
<input type="checkbox"/>	ASG-ALB-instances	i-03c987f687b8eb596	Terminated	t2.micro	-	Vi
<input type="checkbox"/>	ASG-ALB-instances	i-01c766b3b642c8116	Running	t2.micro	2/2 checks passed	Vi
<input type="checkbox"/>	Linux-server-1	i-03fb460939a7ae5e1	Running	t2.micro	2/2 checks passed	Vi
<input type="checkbox"/>	ASG-ALB-instances	i-0f505daf37bb14bae	Running	t2.micro	2/2 checks passed	Vi
<input type="checkbox"/>	ASG-ALB-instances	i-01a362eeb2c7d81ce	Terminated	t2.micro	-	Vi

Modify Launch Template and Edit ASG:

- Go back to Launch template and click edit.
- Set Version (2).

EC2 > Launch templates > Modify template (Create new version)

Modify template (Create new version)

Modifying a template allows you to create a new template version from an existing version. Using versions allows you to manage templates in a structured and controlled way. It also allows you to always use the default version of the template by rolling out updates to templates without having to change a reference to the template name or ID.

Launch template name and version description

Launch template name
ASG-Template-384 (lt-00ce9ba8b0c1fd970)

Template version description
Version(2)
Max 255 chars

Auto Scaling guidance [Info](#)
Select this if you intend to use this template with EC2 Auto Scaling

☐ Provide guidance to help me set up a template that I can use with EC2 Auto Scaling

► Source template

- Edited User data, Add curl commands with public URLs of index.html and image objects from S3 static website bucket which configures in Task 1(a).

User data - optional [Info](#)
Upload a file with your user data or enter it in the field.

[Choose file](#)

```
systemctl enable httpd

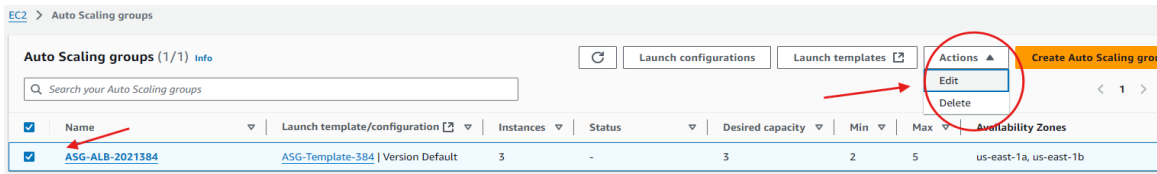
# Create directory for images
mkdir -p /var/www/html/images

# Download website files from the S3 bucket
curl -o /var/www/html/index.html https://my-cloudareus-2021384.s3.us-east-1.amazonaws.com/Staticweb-clouds-are-us/index.html
curl -o /var/www/html/images/cloudservices.jpg https://my-cloudareus-2021384.s3.us-east-1.amazonaws.com/Staticweb-clouds-are-us/images/cloudservices.jpg

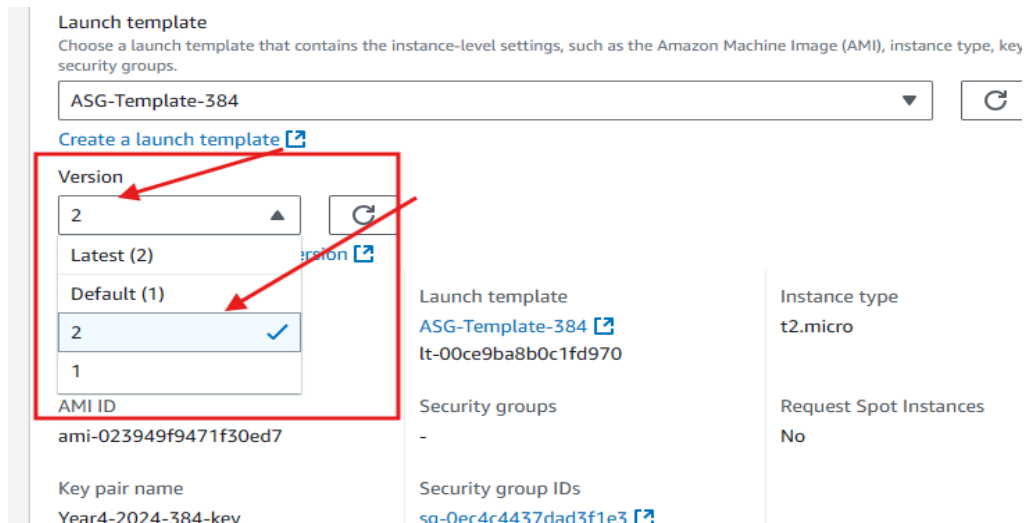
# Add a server name dynamically to the HTML file
INSTANCE_ID=$(curl -s http://169.254.169.254/latest/meta-data/instance-id)
```

☐ User data has already been base64 encoded

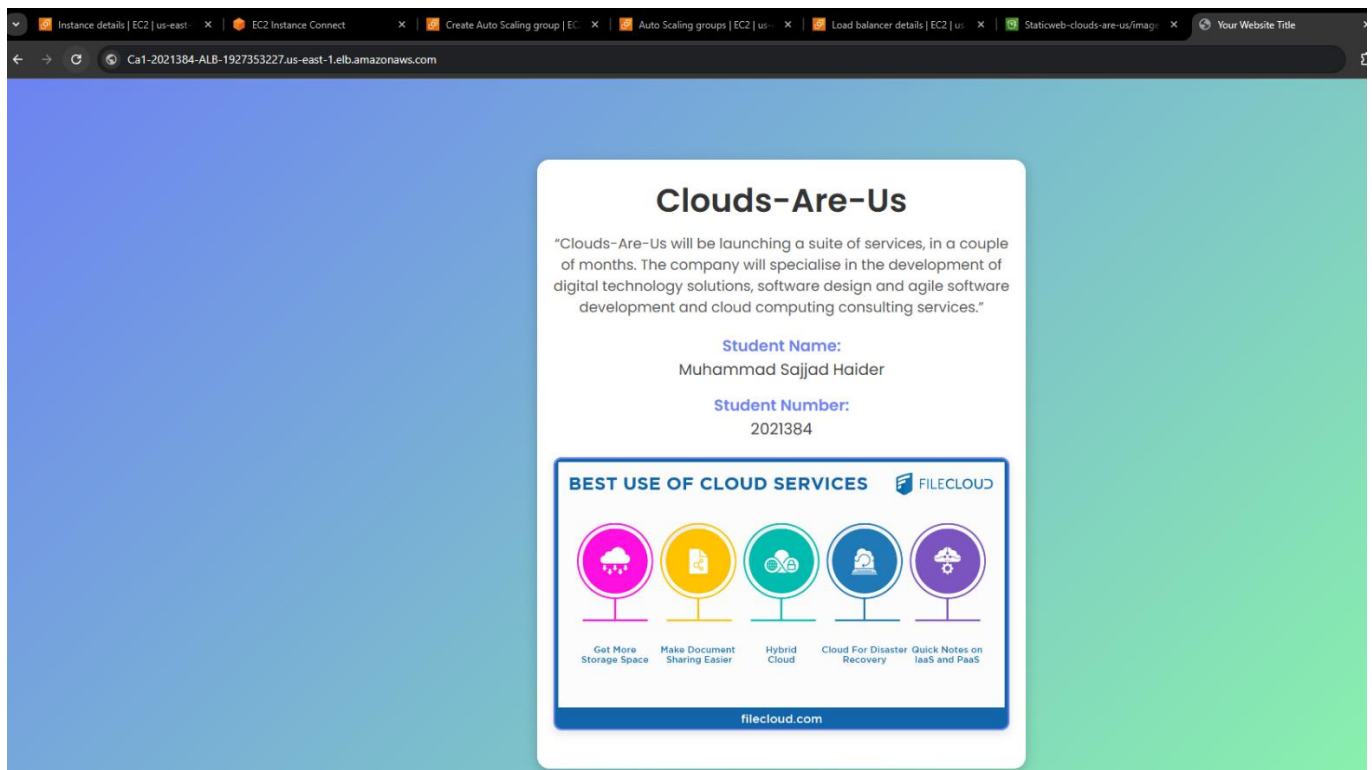
- Edit Auto scaling group for modified Launch template.



- Attached Modified ASG-Template-384 Version 2.



- Copy the DNS name of ALB and search in browser and Clouds-Are-Us web page hosted Successfully.



Q3(b): Research Task: Principles of ASG with ALB

The use of the proposed DigiTech Application Load Balancer (ALB) is to duly spread the operation business across targets similar as IP addresses and EC2 cases, or holders. The load balancing maximizes the vacuity and trustability of DigiTech's apps by icing that one case does not get overwhelmed with business. These are the effects it provides, how it works, and that would be employed in this case the architectural design generalities according to AWS Well-Architected Framework.

The Principle of Operation of DigiTech ALB

Business Distribution:

It uses content, paths, and HTTP heads as parameter to route incoming requests to the applicable target destination depending on set of conditions. This also ensures the stylish but possible utilization of the coffers and response time.

Health Checks:

The ALB always monitors the health of its targets at any one time. The ALB routing intelligent directs business to healthy targets while avoiding cases that have come unhealthy or do not respond.

Subcaste 7 Routing:

In its operation, ALB works at the operation subcaste (Subcaste 7) I/ E it's able of making routing opinions grounded on specific operation- subcaste data. This includes features that can give better and further extents control of operation business to colorful operation waiters, including host grounded or path grounded routing.

Principles for combining ASG with ALB

The operations that are being run by DigiTech have some assurance of being suitable to continue running in the event that commodity is wrong or if there's too important business thanks to the ALB performing business distribution and also health checks.

Scalability: Using the integration of ALB and ASG, DigiTech can have a feature of automatic resource scaling depending on the demand. Improvements in the user experience will occur due to their capacity for traffic handling without owners' interferences.

Cost Efficiency: DigiTech can curb costs by only using what they have to and maintain efficiency by changes its resources based on traffic needs.

Enhanced Security: For enhanced protection against established common web strikes, an ALB can communicate with AWS web application firewall (WAF).

Sources of Information The principles of architectural design will be derived from both primary and secondary research.

Scalability: Scalability is one of the key concepts of architectural principles of the AWS architecture that confer a promise of the application's ability to elastically grow or shrink based on the load requirements. It is possible to add or delete instances of DigiTech based on traffic intensity with the help of association with an ASG of the ALB.

Fault Tolerance: Another concept is the design for fault tolerance. By frequent checking of the health of targets and the directing of traffic towards healthy instances, the ALB also significantly contributes to the formation of an extremely reliable architecture with minimal or no downtime. While using ASG, instances can be horizontally expanded or rebuilt to ensure reliability in the execution of the offered services by DigiTech with no impact on the availability of the application.

To sum up, with regard to its interaction with Auto Scaling Groups, traffic handling capabilities and advocacy of scalability and reliability, the DigiTech ALB enhances the general architecture.

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