

Multi-cloud Disaster Recovery with AWS and Azure

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All the code bases can be found in the github link below: -

https://github.com/shivu9900/CourseAssignment_Submission_Shivakumara_UPGrad

Task 1: Infrastructure Provisioning

AWS Setup:

Created VPC named DR-VPC in AWS

The screenshot shows the AWS VPC dashboard. In the top navigation bar, it says 'VPC > Your VPCs > vpc-04f2f785797301ebd'. A green banner at the top right says 'You successfully created vpc-04f2f785797301ebd / DR-VPC'. The main area is titled 'vpc-04f2f785797301ebd / DR-VPC'. On the left, there's a sidebar for 'Virtual private cloud' with options like 'Your VPCs', 'Subnets', 'Route tables', etc. The 'Details' tab is selected in the center. Key details shown include:

VPC ID	vpc-04f2f785797301ebd	State	Available	Block Public Access	Off	DNS hostnames	Disabled
DNS resolution	Enabled	Tenancy	default	DHCP option set	dopt-08772501918fbfe85	Main route table	rtb-0234f673953730a64
Main network ACL	acl-0922d35e5b276799d	Default VPC	No	IPv4 CIDR	10.0.0.0/16	IPv6 pool	-
IPv6 CIDR (Network border group)	-	Network Address Usage metrics	Disabled	Route 53 Resolver DNS Firewall rule groups	Failed to load rule groups	Owner ID	814845532308

Created 2 public and 2 private subnet with AZ as us-east-1a and us-east-1b named public-subnet-1, public-subnet-2, private-subnet-1, private-subnet-2

The screenshot shows the AWS Subnets page. A green banner at the top says 'You have successfully created 4 subnets: subnet-04c60025fe8686751, subnet-0670614a8cab909e7, subnet-014737939200bf88a, subnet-0ec5ef645a48f8c0'. The main table lists the subnets:

Name	Subnet ID	State	VPC
private-subnet-1	subnet-014737939200bf88a	Available	vpc-04f2f785797301ebd DR-V...
public-subnet-1	subnet-04c60025fe8686751	Available	vpc-04f2f785797301ebd DR-V...
public-subnet-2	subnet-0670614a8cab909e7	Available	vpc-04f2f785797301ebd DR-V...
private-subnet-2	subnet-0ec5ef645a48f8c0	Available	vpc-04f2f785797301ebd DR-V...

Below the table, a section titled 'Select a subnet' shows the subnet ranges and associated AZs:

Range	AZ	Description
10.0.3.0/24	-	-
10.0.1.0/24	-	-
10.0.2.0/24	-	-
10.0.4.0/24	-	-

Created new Internet Gateway named DR-IGW and attached to DR-VPC VPC

Internet gateway igw-0011405bb071cbc41 successfully attached to vpc-04f2f785797301ebd

igw-0011405bb071cbc41 / DR-IGW

Actions ▾

Details [Info](#)

Internet gateway ID igw-0011405bb071cbc41	State Attached	VPC ID vpc-04f2f785797301ebd DR-VPC	Owner 814845532308
--	-----------------------------------	--	---------------------------------------

Tags (1)

Search tags	
Key	Value
Name	DR-IGW

[Manage tags](#)

< 1 > | [⚙️](#)

Created new NAT Gateway named DR-NATGW and attached to DR-VPC VPC

NAT gateway nat-0e7716d89145f00f7 | DR-NATGW was created successfully.

nat-0e7716d89145f00f7 / DR-NATGW

Actions ▾

Details

NAT gateway ID nat-0e7716d89145f00f7	Connectivity type Public	State Pending	State message Info -
NAT gateway ARN arn:aws:ec2:us-east-1:814845532308:natgateway/nat-0e7716d89145f00f7	Primary public IPv4 address -	Primary private IPv4 address -	Primary network interface ID -
VPC vpc-04f2f785797301ebd / DR-VPC	Subnet subnet-04c60025fe8686751 / public-subnet-1	Created Sunday, November 16, 2025 at 11:51:43 G MT+5:30	Deleted -

[Secondary IPv4 addresses](#) [Monitoring](#) [Tags](#)

Secondary IPv4 addresses

[Edit secondary IPv4 address associations](#)

Search	Private IPv4 address	Network interface ID	Status	Failure message
------------------------	--------------------------------------	--------------------------------------	------------------------	---------------------------------

Secondary IPv4 addresses are not available for this nat gateway.

Created Public Route table named RT-Public

rtb-0a741599600376454 / RT-Public

Actions ▾

Details [Info](#)

Route table ID rtb-0a741599600376454	Main No	Explicit subnet associations -	Edge associations -
VPC vpc-04f2f785797301ebd DR-VPC	Owner ID 814845532308		

[Routes](#) [Subnet associations](#) [Edge associations](#) [Route propagation](#) [Tags](#)

Routes (2)

[Edit routes](#)

Destination	Target	Status	Propagated	Route Origin
0.0.0.0/0	igw-0011405bb071cbc41	Active	No	Create Route
10.0.0.0/16	local	Active	No	Create Route Table

Created Private Route table named RT-Private

Updated routes for rtb-0d93f04e01aad1bca / RT-Private successfully

rtb-0d93f04e01aad1bca / RT-Private

Details **Info**

Route table ID: rtb-0d93f04e01aad1bca
Main: No
Owner ID: 814845532308

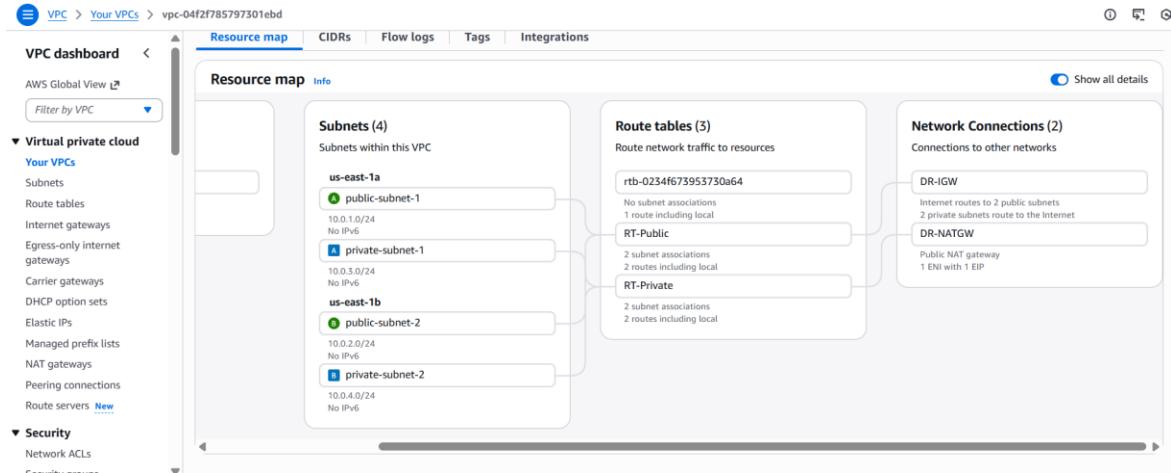
Explicit subnet associations: -
Edge associations: -

Routes **Subnet associations** **Edge associations** **Route propagation** **Tags**

Routes (2)

Destination	Target	Status	Propagated	Route Origin
0.0.0.0/0	nat-0e7716d89145f00f7	Active	No	Create Route
10.0.0.0/16	local	Active	No	Create Route Table

Detailed Resource map of DR-VPC



Security group named **SG-Web** created with SSH port 22 and HTTP port 80 opened in inbound rules

⌚ Security group (sg-09056a2707adb37ef | SG-Web) was created successfully
▶ Details

sg-09056a2707adb37ef - SG-Web

Actions ▾

Details																															
Security group name <input type="checkbox"/> SG-Web	Security group ID <input type="checkbox"/> sg-09056a2707adb37ef																														
Owner <input type="checkbox"/> 814845532308	Description <input type="checkbox"/> webserver security group																														
	VPC ID <input type="checkbox"/> vpc-04f2f785797301ebd																														
Inbound rules Outbound rules Sharing - new VPC associations - new Tags																															
Inbound rules (2)																															
<table border="1"><thead><tr><th colspan="2">Search</th><th colspan="2">Manage tags</th><th colspan="2">Edit inbound rules</th></tr><tr><th>Name</th><th>Security group rule ID</th><th>IP version</th><th>Type</th><th>Protocol</th><th>Port range</th></tr><tr><th>Source</th><th></th><th></th><th></th><th></th><th></th></tr></thead><tbody><tr><td>-</td><td>sgr-018ed488e4c8e3f00</td><td>IPv4</td><td>SSH</td><td>TCP</td><td>22</td></tr><tr><td>-</td><td>sgr-047757f60399d5e63</td><td>IPv4</td><td>HTTP</td><td>TCP</td><td>80</td></tr></tbody></table>		Search		Manage tags		Edit inbound rules		Name	Security group rule ID	IP version	Type	Protocol	Port range	Source						-	sgr-018ed488e4c8e3f00	IPv4	SSH	TCP	22	-	sgr-047757f60399d5e63	IPv4	HTTP	TCP	80
Search		Manage tags		Edit inbound rules																											
Name	Security group rule ID	IP version	Type	Protocol	Port range																										
Source																															
-	sgr-018ed488e4c8e3f00	IPv4	SSH	TCP	22																										
-	sgr-047757f60399d5e63	IPv4	HTTP	TCP	80																										

Created EC2 Key pair **dr-keypair** as pem file

⌚ Successfully created key pair

Key pairs (1) Info

Actions ▾ **Create key pair**

Find Key Pair by attribute or tag											
<table border="1"><thead><tr><th>Name</th><th>Type</th><th>Created</th><th>Fingerprint</th><th>ID</th></tr></thead><tbody><tr><td>dr-keypair</td><td>rsa</td><td>2025/11/16 12:02 GMT+5:30</td><td>98:35:75:2b:27:7b:cd:bc:a9:bc:37:e8:30:40:6c:84...</td><td>key-05d4b...</td></tr></tbody></table>		Name	Type	Created	Fingerprint	ID	dr-keypair	rsa	2025/11/16 12:02 GMT+5:30	98:35:75:2b:27:7b:cd:bc:a9:bc:37:e8:30:40:6c:84...	key-05d4b...
Name	Type	Created	Fingerprint	ID							
dr-keypair	rsa	2025/11/16 12:02 GMT+5:30	98:35:75:2b:27:7b:cd:bc:a9:bc:37:e8:30:40:6c:84...	key-05d4b...							

Created EC2 Machine named App-Machine in public subnet 1

The screenshot shows the AWS CloudWatch Metrics console for an EC2 instance. The instance summary for 'i-059aac8b6dc559b45 (App-Machine)' is displayed. Key details include:

- Instance ID:** i-059aac8b6dc559b45
- Public IPv4 address:** 44.204.190.114
- Private IP4 addresses:** 10.0.1.157
- Instance state:** Running
- Private IP DNS name (IPv4 only):** ip-10-0-1-157.ec2.internal
- Public DNS:** -
- Instance type:** t2.micro
- Elastic IP addresses:** -
- VPC ID:** vpc-04f2f785797301ebd (DR-VPC)
- AWS Compute Optimizer finding:** A warning message from AWS Compute Optimizer stating that the user is not authorized to perform certain actions due to lack of identity-based policy.

Able to SSH into App-Machine with public IP :44.204.190.114 from local machine

```
$ ssh -i "dr-keypair.pem" ubuntu@44.204.190.114
The authenticity of host '44.204.190.114 (44.204.190.114)' can't be established.
ED25519 key fingerprint is SHA256:JDal7pNWRLr9vsWjgl+ViCQi4xQGYwhTJtQyVx4DksM.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '44.204.190.114' (ED25519) to the list of known hosts.
Welcome to Ubuntu 24.04.3 LTS (GNU/Linux 6.14.0-1015-aws x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/pro

System information as of Sun Nov 16 06:42:15 UTC 2025

  System load:  0.0          Processes:           110
  Usage of /:   25.9% of 6.71GB   Users logged in:     0
  Memory usage: 21%            IPv4 address for enx0: 10.0.1.157
  Swap usage:   0%

Expanded Security Maintenance for Applications is not enabled.

0 updates can be applied immediately.

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

The list of available updates is more than a week old.
To check for new updates run: sudo apt update

The programs included with the Ubuntu system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*copyright.

Ubuntu comes with ABSOLUTELY NO WARRANTY, to the extent permitted by
applicable law.

To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

ubuntu@ip-10-0-1-157:~$ |
```

Created another EC2 Machine named Tools-Machine in public subnet 2

Instance summary for i-0131c2e1e03f7338b (Tools-Machine) Info			
		Connect	Instance state ▾
		Actions ▾	
Updated less than a minute ago			
Instance ID	i-0131c2e1e03f7338b	Public IPv4 address	Private IPv4 addresses
IPv6 address	-	98.81.254.10 open address ↗	10.0.2.237
Hostname type	IP name: ip-10-0-2-237.ec2.internal	Instance state	Public DNS
Answer private resource DNS name	-	Running	-
Auto-assigned IP address	98.81.254.10 [Public IP]	Private IP DNS name (IPv4 only)	Elastic IP addresses
VPC ID	vpc-04f2f785797301ebd (DR-VPC)	ip-10-0-2-237.ec2.internal	AWS Compute Optimizer finding
IAM Role	-	Subnet ID	User: arn:aws:sts::814845532308:federated-user/shivakumaran d95@gmail.com is not authorized to perform: compute-optimizer:GetEnrollmentStatus on resource: * because no identity-based policy allows the compute-optimizer:GetEnrollmentStatus action
		subnet-0670614a8cab909e7 (public-subnet-2)	Retry
			Auto Scaling Group name
			-

Able to SSH into Tools-Machine with public IP: 98.81.254.10 from local machine

```
$ ssh -i "dr-keypair.pem" ubuntu@98.81.254.10
The authenticity of host '98.81.254.10 (98.81.254.10)' can't be established.
ED25519 key fingerprint is SHA256:T8PumOk/wjdEDBbFLTzhDTjGOYL7RAswQvE+udJJoOo.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '98.81.254.10' (ED25519) to the list of known hosts.
Welcome to Ubuntu 24.04.3 LTS (GNU/Linux 6.14.0-1015-aws x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/pro

System information as of Sun Nov 16 06:44:41 UTC 2025

  System load:  0.0           Processes:          108
  Usage of /:   25.9% of 6.71GB   Users logged in:     0
  Memory usage: 20%            IPv4 address for enx0: 10.0.2.237
  Swap usage:   0%

Expanded Security Maintenance for Applications is not enabled.

0 updates can be applied immediately.

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

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applicable law.

To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

ubuntu@ip-10-0-2-237:~$ |
```

Azure Setup:

Created New Resource group named dr-rg

The screenshot shows the Azure Resource groups page. At the top, there are navigation links for Home, Resource groups, Summarize my costs by service, How to manage changes with deployment tools?, and Export resource groups using Bicep or Terraform. Below the header, there are buttons for Create, Manage view, Refresh, Export to CSV, Open query, Assign tags, and Add to service group. A message indicates that the user is viewing a new version of the Browse experience and provides a link to access the old experience. There are filter options for Subscription (equals all), Location (equals all), and Add filter. The main table lists one resource group: 'dr-rg'. The table has columns for Name, Subscription, and Location. The 'dr-rg' entry shows it belongs to 'npupgradl-1695790677755' and is located in 'East US'.

Name	Subscription	Location
dr-rg	npupgradl-1695790677755	East US

Created Vnet named dr-vnet and 2 subnets are added

The screenshot shows the Azure Virtual network (Vnet) overview page for 'dr-vnet'. The top navigation bar includes Home, dr-vnet, Overview, and other tabs like Health, Troubleshoot, and Evaluate. The main content area has a search bar and buttons for Move, Delete, Refresh, and Give feedback. On the left, there's a sidebar with links for Activity log, Access control (IAM), Tags, Diagnose and solve problems, Resource visualizer, Settings, Monitoring, and Automation. The 'Overview' tab is selected. The 'Essentials' section displays the following details:

- Resource group: dr-rg
- Location: East US
- Subscription: npupgradl-1695790677755
- Subscription ID: 552cb9f8-c936-4ec0-87be-ff35d4737fcf
- Address space: 10.10.0.0/16
- Subnets: 2 subnets
- DNS servers: Azure provided DNS service
- BGP community string: Configure
- Virtual network ID: 52f09c75-755b-492e-80b3-ffa6f90d4240

At the bottom, there are tabs for Topology, Properties, Capabilities (5), Recommendations, and Tutorials. The 'Capabilities (5)' tab is currently active.

Created NSG named dr-nsg

Home > CreateNetworkSecurityGroupBladeV2-20251116122900 | Overview >

dr-nsg Network security group

Diagnose connectivity issues related to this security group | How do I create an alert to track firewall metric failures? | Retrieve detailed information for troubleshooting security rules

Search

Overview

Activity log

Access control (IAM)

Tags

Diagnose and solve problems

Resource visualizer

Settings

- Inbound security rules
- Outbound security rules
- Network interfaces
- Subnets
- Properties
- Locks

Monitoring

Essentials

Resource group (move) : dr-rg

Location : East US

Subscription (move) : npupgradl-1695790677755

Subscription ID : 552cb9f8-c936-4ec0-87be-ff35d4737fcf

Tags (edit) : Add tags

Custom security rules : 2 inbound, 0 outbound

Associated with : 0 subnets, 0 network interfaces

Filter by name

Priority ↑↓	Name ↑↓	Port ↑↓	Protocol ↑↓	Source ↑↓	Destination ↑↓	Action ↑↓
100	sshPortAllowed	22	TCP	Any	Any	Allow
110	httpAllowed	80	TCP	Any	Any	Allow
65000	AllowVnetInBound	Any	Any	VirtualNetwork	VirtualNetwork	Allow
65001	AllowAzureLoadBalanc...	Any	Any	AzureLoadBalancer	Any	Allow
65500	DenyAllInBound	Any	Any	Any	Any	Deny

JSON View

Created virtual machine named App-VM

Help me copy this VM in any region | Manage this VM with Azure CLI

App-VM Virtual machine

Search

Overview

Activity log

Access control (IAM)

Tags

Diagnose and solve problems

Resource visualizer

Connect

- Connect
- Bastion

Networking

Settings

Availability + scale

Security

Backup & disaster recovery

Connect

Start

Restart

Stop

Hibernate

Capture

Delete

Refresh

Open in mobile

Feedback

CLI / PS

Essentials

Resource group (move) : dr-rg

Status : Running

Location : East US (Zone 1)

Subscription (move) : npupgradl-1695790677755

Subscription ID : 552cb9f8-c936-4ec0-87be-ff35d4737fcf

Availability zone : 1

Operating system : Linux (ubuntu 24.04)

Size : Standard DS1 v2 (1 vcpu, 3.5 GiB memory)

Primary NIC public IP : 20.121.42.105
1 associated public IPs

Virtual network/subnet : dr-vnet/app-subnet

DNS name : Not configured

Health state : -

Time created : 11/16/2025, 7:18 AM UTC

Tags (edit) : Add tags

Properties Monitoring Capabilities (7) Recommendations Tutorials

JSON View

Tested connectivity to App-VM Public IP:20.121.42.105 from local through SSH

```
$ ssh -i azurekey.pem azureuser@20.121.42.105
Welcome to Ubuntu 24.04.3 LTS (GNU/Linux 6.14.0-1012-azure x86_64)

 * Documentation: https://help.ubuntu.com
 * Management: https://landscape.canonical.com
 * Support: https://ubuntu.com/pro

System information as of Sun Nov 16 07:24:35 UTC 2025

  System load: 0.11          Processes:           117
  Usage of /:   5.6% of 28.02GB  Users logged in:      0
  Memory usage: 8%            IPv4 address for eth0: 10.10.1.5
  Swap usage:   0%

Expanded Security Maintenance for Applications is not enabled.

0 updates can be applied immediately.

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

The list of available updates is more than a week old.
To check for new updates run: sudo apt update

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applicable law.

To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

azureuser@App-VM:~$
```

Created virtual machine named Tools-VM

The screenshot shows the Azure portal interface for a virtual machine named 'Tools-VM'. The top navigation bar includes 'Home', 'CreateVm-canonical.ubuntu-24_04-lts-server-20251116125703 | Overview', and a search bar. Below the navigation is a toolbar with icons for 'Help me copy this VM in any region' and 'Manage this VM with Azure CLI'. The main content area has a left sidebar with links like 'Overview', 'Activity log', 'Access control (IAM)', 'Tags', 'Diagnose and solve problems', 'Resource visualizer', 'Connect', 'Networking', 'Settings', 'Availability + scale', 'Security', 'Backup + disaster recovery', 'Operations', and 'Monitoring'. The right pane displays the 'Essentials' section with detailed information:

Property	Value
Resource group	dr-g
Status	Running
Location	East US (Zone 1)
Subscription	npupgradl-1695790677755
Subscription ID	552cb9f8-c936-4ec0-87be-f35d4737fcf
Availability zone	1
Operating system	Linux (ubuntu 24.04)
Size	Standard DS1 v2 (1 vcpu, 3.5 GiB memory)
Primary NIC public IP	172.190.112.221 1 associated public IPs
Virtual network/subnet	dr-vnet/tools-subnet
DNS name	Not configured
Health state	-
Time created	11/16/2025, 7:30 AM UTC

Below the essentials section are 'Tags (edit)' and 'Add tags' buttons. At the bottom of the right pane are tabs for 'Properties', 'Monitoring', 'Capabilities (7)', 'Recommendations', 'Tutorials', 'Virtual machine', and 'Networking'.

Tested connectivity to Tools-VM public IP: 172.190.112.221 from local through SSH

```
azia-AC117C:\Users\azia\Downloads$ ssh -i azurekey.pem azureuser@172.190.112.221
Welcome to Ubuntu 24.04.3 LTS (GNU/Linux 6.14.0-1012-azure x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:    https://landscape.canonical.com
 * Support:       https://ubuntu.com/pro

System information as of Sun Nov 16 07:34:55 UTC 2025

  System load:  0.09           Processes:      129
  Usage of /:   5.6% of 28.02GB  Users logged in:  0
  Memory usage: 8%            IPv4 address for eth0: 10.10.2.4
  Swap usage:   0%

Expanded Security Maintenance for Applications is not enabled.

0 updates can be applied immediately.

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

The list of available updates is more than a week old.
To check for new updates run: sudo apt update

The programs included with the Ubuntu system are free software;
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individual files in /usr/share/doc/*/*copyright.

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applicable law.

To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

azureuser@Tools-VM:~$
```

Task 2: Configuration Management

Installed Ansible on AWS Tools machine

```
sudo apt update
sudo apt install -y software-properties-common
sudo add-apt-repository --yes --update ppa:ansible/ansible
sudo apt install -y ansible
ansible --version # confirm installation
```

```
NO VM guests are running outdated hypervisor (qemu) binaries on this host.
ubuntu@ip-10-0-2-237:~$ ansible --version
ansible [core 2.19.4]
  config file = /etc/ansible/ansible.cfg
  configured module search path = ['/home/ubuntu/.ansible/plugins/modules', '/usr/share/ansible/plugins/modules']
  ansible python module location = /usr/lib/python3/dist-packages/ansible
  ansible collection location = /home/ubuntu/.ansible/collections:/usr/share/ansible/collections
  executable location = /usr/bin/ansible
  python version = 3.12.3 (main, Aug 14 2025, 17:47:21) [GCC 13.3.0] (/usr/bin/python3)
  jinja version = 3.1.2
  pyyaml version = 6.0.1 (with libyaml v0.2.5)
ubuntu@ip-10-0-2-237:~$ chown ubuntu:ubuntu ~/.ssh/*.pem
ubuntu@ip-10-0-2-237:~$ vi inventory.ini
ubuntu@ip-10-0-2-237:~$ ssh -i ~/ssh/dr-keypair.pem ubuntu@44.204.190.114
The authenticity of host '44.204.190.114 (44.204.190.114)' can't be established.
ED25519 key fingerprint is SHA256:JDal7pnWRLr9vswjgl+ViCQi4xQGYwhtJtQyvx4bKSM.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '44.204.190.114' (ED25519) to the list of known hosts.
Welcome to Ubuntu 24.04.3 LTS (GNU/Linux 6.14.0-1015-aws x86_64)
```

from local workstation copied .pem file to Tools Machine using below commands

```
scp -i ~/Downloads/dr-keypair.pem ~/Downloads/dr-keypair.pem
ubuntu@98.81.254.10:/home/ubuntu/.ssh/dr-keypair.pem

scp -i ~/Downloads/azurekey.pem ~/Downloads/azurekey.pem
ubuntu@98.81.254.10:/home/ubuntu/.ssh/azurekey.pem

chmod 600 /home/ubuntu/.ssh/azurekey.pem

chown azureuser:azureuser /home/ubuntu/.ssh/dr-keypair.pem
```

Tested connectivity from tool machine to app machine (AWS) (IP:44.204.190.114)

```
ubuntu@ip-10-0-2-237:~$ ssh -i ~/.ssh/dr-keypair.pem ubuntu@44.204.190.114
The authenticity of host '44.204.190.114 (44.204.190.114)' can't be established.
ED25519 key fingerprint is SHA256:JDal7pNwRLr9vsWjgl+ViCQi4xQGYwhtJtQyVx4DkSM.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '44.204.190.114' (ED25519) to the list of known hosts.
Welcome to Ubuntu 24.04.3 LTS (GNU/Linux 6.14.0-1015-aws x86_64)
```

Tested connectivity from tool machine to app machine (Azure)(IP:20.121.42.105)

```
ubuntu@ip-10-0-2-237:~$ ssh -i ~/.ssh/azurekey.pem azureuser@20.121.42.105
The authenticity of host '20.121.42.105 (20.121.42.105)' can't be established.
ED25519 key fingerprint is SHA256:E4Uy+RaOtTMo2mDunyA24xrxxcJ82Rz00dg1SXwz8/4.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '20.121.42.105' (ED25519) to the list of known hosts.
Welcome to Ubuntu 24.04.3 LTS (GNU/Linux 6.14.0-1012-azure x86_64)

 * Documentation:  https://help.ubuntu.com
 * Management:     https://landscape.canonical.com
 * Support:        https://ubuntu.com/pro

System information as of Sun Nov 16 08:06:40 UTC 2025

 System load:  0.0          Processes:           115
 Usage of /:   5.7% of 28.02GB  Users logged in:    0
 Memory usage: 7%          IPv4 address for eth0: 10.10.1.5
 Swap usage:   0%
```

Used below `inventory.ini` inventory file to mention web servers name

```
[webservers]

aws_app ansible_host=44.204.190.114 ansible_user=ubuntu
ansible_ssh_private_key_file=/home/ubuntu/.ssh/dr-keypair.pem

azure_app ansible_host=20.121.42.105 ansible_user=azureuser
ansible_ssh_private_key_file=/home/ubuntu/.ssh/azurekey.pem
```

used below code `install_nginx.yml` file as playbook file

```
---
- name: Install and verify nginx on all web servers
  hosts: webservers
  become: yes
  gather_facts: yes
  vars:
    welcome_content: "<h1>Welcome to Nginx</h1>"
  tasks:
    - name: Ensure apt cache is updated
      ansible.builtin.apt:
        update_cache: yes
        cache_valid_time: 3600
    - name: Install Nginx
      ansible.builtin.apt:
        name: nginx
        state: present
    - name: Ensure nginx service is enabled and started
      ansible.builtin.service:
        name: nginx
        state: started
        enabled: yes
    - name: Create custom index.html
      ansible.builtin.copy:
        dest: /var/www/html/index.html
        content: "{{ welcome_content }}"
        owner: root
        group: root
        mode: '0644'
        notify: Restart nginx
    - name: Wait for HTTP port 80 to become open
      ansible.builtin.wait_for:
        host: "{{ ansible_host | default(inventory_hostname) }}"
        port: 80
        timeout: 30
        state: started
    - name: Verify that HTTP returns Welcome to Nginx
      ansible.builtin.uri:
        url: "http://{{ ansible_host }}"
        return_content: yes
```

```

    status_code: 200
    register: web_response
    retries: 3
    delay: 2
    until: web_response.status == 200
  - name: Assert expected content present
    ansible.builtin.assert:
      that:
        - "'Welcome to Nginx' in web_response.content"
  handlers:
    - name: Restart nginx
      ansible.builtin.service:
        name: nginx
        state: restarted

```

executed below command to deploy the playbook

```
ansible-playbook -i inventory.ini install_nginx.yml
```

Below is the successful connection and nginx installation on app servers through ansible

```

ubuntu@ip-10-0-2-237:~$ vi inventory.ini
ubuntu@ip-10-0-2-237:~$ ansible-playbook -i inventory.ini install_nginx.yml
PLAY [Install and verify nginx on all web servers] ****
TASK [Gathering Facts] ****
[WARNING]: Host 'aws_app' is using the discovered Python interpreter at '/usr/bin/python3.12', but future installation of another Python interpreter could cause a different interpreter to be discovered. See https://docs.ansible.com/ansible-core/2.19/reference_appendices/interpreter_discovery.html for more information.
ok: [aws_app]
[WARNING]: Host 'azure_app' is using the discovered Python interpreter at '/usr/bin/python3.12', but future installation of another Python interpreter could cause a different interpreter to be discovered. See https://docs.ansible.com/ansible-core/2.19/reference_appendices/interpreter_discovery.html for more information.
ok: [azure_app]

TASK [Ensure apt cache is updated] ****
changed: [aws_app]
changed: [azure_app]

TASK [Install Nginx] ****
changed: [aws_app]
changed: [azure_app]

TASK [Ensure nginx service is enabled and started] ****
ok: [aws_app]
ok: [azure_app]

TASK [Create custom index.html] ****
changed: [aws_app]
changed: [azure_app]

TASK [Wait for HTTP port 80 to become open] ****
ok: [aws_app]
ok: [azure_app]

TASK [Verify that HTTP returns Welcome to Nginx] ****
ok: [aws_app]
ok: [azure_app]

TASK [Assert expected content present] ****
ok: [aws_app] => {
  "changed": false,
  "msg": "All assertions passed"
}
ok: [azure_app] => {
  "changed": false,
  "msg": "All assertions passed"
}

RUNNING HANDLER [Restart nginx] ****

```

```
RUNNING HANDLER [Restart nginx] ****
changed: [aws_app]
changed: [azure_app]

PLAY RECAP ****
aws_app : ok=9    changed=4    unreachable=0    failed=0    skipped=0    rescued=0    ignored=0
azure_app : ok=9    changed=4    unreachable=0    failed=0    skipped=0    rescued=0    ignored=0

ubuntu@ip-10-0-2-237:~$ |
```

Testing from Tools Machine to App-server (AWS) (IP:44.204.190.114)

```
ubuntu@ip-10-0-2-237:~$ curl http://44.204.190.114
<h1>Welcome to Nginx</h1>ubuntu@ip-10-0-2-237:~$ |
```

Accessing application via http port 80: App-server (AWS)



Testing from Tools Mahine to App-server (Azure) (IP:20.121.42.105)

```
ubuntu@ip-10-0-2-237:~$ curl http://20.121.42.105
<h1>Welcome to Nginx</h1>ubuntu@ip-10-0-2-237:~$ |
```

Accessing application via http port 80: App-server (Azure)



Task 3: Application Deployment

Created separate html file for aws App server

index-aws.html

```
<!DOCTYPE html>
<html>
<head>
    <title>Welcome to AWS</title>
</head>
<body>
<h1>Welcome to AWS</h1>
<p>This page was deployed by Ansible.</p>
</body>
</html>
```

Created separate html file for aws App server

index-azure.html

```
<!DOCTYPE html>
<html>
<head>
    <title>Welcome to Azure</title>
</head>
<body>
<h1>Welcome to Azure</h1>
<p>This page was deployed by Ansible.</p>
</body>
</html>
```

Created new inventory file to deploy separate html files on different app servers

inventory.ini

```
[webservers]
aws_app ansible_host=44.204.190.114 ansible_user=ubuntu
ansible_ssh_private_key_file=/home/ubuntu/.ssh/dr-keypair.pem cloud=aws
azure_app ansible_host=20.121.42.105 ansible_user=azureuser
ansible_ssh_private_key_file=/home/ubuntu/.ssh/azurekey.pem cloud=azure
```

New playbook file to deploy separate html files on different app servers

deploy_index_pages.yml

```
---
- name: Deploy cloud-specific index pages and ensure nginx serves them
  hosts: webservers
  become: yes
  gather_facts: yes

  tasks:
    - name: Ensure apt cache is updated
      ansible.builtin.apt:
        update_cache: yes
        cache_valid_time: 3600

    - name: Install nginx if not present
      ansible.builtin.apt:
        name: nginx
        state: present

    - name: Ensure nginx service is enabled and started
      ansible.builtin.service:
        name: nginx
        state: started
        enabled: yes

    - name: Deploy cloud-specific index file
      ansible.builtin.copy:
```

```
src: "index-{{ cloud }}.html"
dest: /var/www/html/index.html
owner: root
group: root
mode: '0644'
notify: Reload nginx

- name: Wait for nginx to be ready
  ansible.builtin.wait_for:
    host: "{{ ansible_host }}"
    port: 80
    timeout: 30

- name: Verify page contents
  ansible.builtin.uri:
    url: "http://{{ ansible_host }}"
    return_content: yes
    status_code: 200
  register: resp

- name: Assert correct content is shown
  ansible.builtin.assert:
    that:
      - "'Welcome to AWS' in resp.content if cloud == 'aws' else 'Welcome to Azure' in resp.content"

handlers:
- name: Reload nginx
  ansible.builtin.service:
    name: nginx
    state: restarted
```

Below is the Deployment status:

```
ubuntu@ip-10-0-2-237:~$ vi index_azure.html
ubuntu@ip-10-0-2-237:~$ ansible-playbook -i inventory.ini deploy_index_pages.yml

PLAY [Deploy cloud-specific index pages and ensure nginx serves them] ****
TASK [Gathering Facts] ****
[WARNING]: Host 'aws_app' is using the discovered Python interpreter at '/usr/bin/python3.12', but future installation of another Python interpreter could cause a different interpreter to be discovered. See https://docs.ansible.com/ansible-core/2.19/reference_appendices/interpreter_discovery.html for more information.
ok: [aws_app]
[WARNING]: Host 'azure_app' is using the discovered Python interpreter at '/usr/bin/python3.12', but future installation of another Python interpreter could cause a different interpreter to be discovered. See https://docs.ansible.com/ansible-core/2.19/reference_appendices/interpreter_discovery.html for more information.
ok: [azure_app]

TASK [Ensure apt cache is updated] ****
ok: [aws_app]
ok: [azure_app]

TASK [Install nginx if not present] ****
ok: [aws_app]
ok: [azure_app]

TASK [Ensure nginx service is enabled and started] ****
ok: [aws_app]
ok: [azure_app]

TASK [Deploy cloud-specific index file] ****
changed: [aws_app]
changed: [azure_app]

TASK [Wait for nginx to be ready] ****
ok: [aws_app]
ok: [azure_app]

TASK [Verify page contents] ****
ok: [aws_app]
ok: [azure_app]

TASK [Assert correct content is shown] ****
ok: [aws_app] => {
    "changed": false,
    "msg": "All assertions passed"
}

ok: [azure_app] => {
    "changed": false,
    "msg": "All assertions passed"
}

RUNNING HANDLER [Reload nginx] ****
changed: [aws_app]
changed: [azure_app]

PLAY RECAP ****
aws_app : ok=9    changed=2    unreachable=0    failed=0     skipped=0    rescued=0    ignored=0
azure_app : ok=9    changed=2    unreachable=0    failed=0     skipped=0    rescued=0    ignored=0

ubuntu@ip-10-0-2-237:~$ |
```

Connecting to App-server (AWS) (IP:44.204.190.114)

```
ubuntu@ip-10-0-2-237:~$ curl http://44.204.190.114
<!DOCTYPE html>
<html>
<head>
    <title>Welcome to AWS</title>
</head>
<body>
<h1>Welcome to AWS</h1>
<p>This page was deployed by Ansible.</p>
</body>
</html>
ubuntu@ip-10-0-2-237:~$ |
```

Accessing application via http port 80: App-server (AWS) (IP:44.204.190.114)



Welcome to AWS

This page was deployed by Ansible.

Connecting to App-server (Azure) (IP:20.121.42.105)

```
ubuntu@ip-10-0-2-237:~$ curl http://20.121.42.105
<!DOCTYPE html>
<html>
<head>
    <title>Welcome to Azure</title>
</head>
<body>
<h1>Welcome to Azure</h1>
<p>This page was deployed by Ansible.</p>
</body>
</html>
ubuntu@ip-10-0-2-237:~$
```

Accessing application via http port 80: App-server (Azure) (IP:20.121.42.105)



Welcome to Azure

This page was deployed by Ansible.

Task 4: Jenkins Setup for Continuous Deployment

Installed Java using the steps below before installing Jenkins on Tool Machine

```
sudo apt update
sudo apt install -y openjdk-17-jdk
```

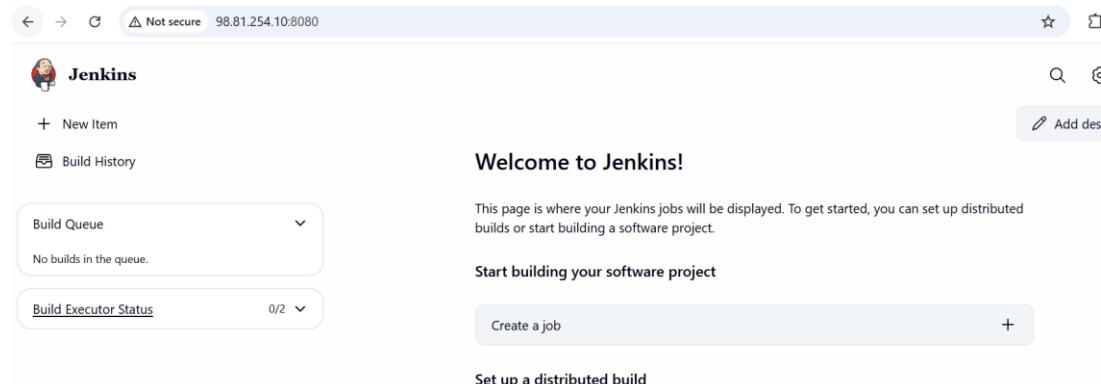
```
at executable.main.main.main.java.555
ubuntu@ip-10-0-2-237:~$ java -version
openjdk version "17.0.16" 2025-07-15
OpenJDK Runtime Environment (build 17.0.16+8-Ubuntu-0ubuntu124.04.1)
OpenJDK 64-Bit Server VM (build 17.0.16+8-Ubuntu-0ubuntu124.04.1, mixed mode, sharing)
ubuntu@ip-10-0-2-237:~$
```

Installed Jenkins with below commands

```
sudo apt update
sudo apt install -y jenkins
sudo systemctl enable jenkins
sudo systemctl start Jenkins
```

```
ubuntu@ip-10-0-2-237:~$ sudo systemctl status jenkins
● jenkins.service - Jenkins Continuous Integration Server
   Loaded: loaded (/usr/lib/systemd/system/jenkins.service; enabled; preset: enabled)
   Active: active (running) since Sun 2025-11-16 09:22:37 UTC; 2min 29s ago
     Main PID: 6273 (java)
        Tasks: 38 (limit: 1121)
       Memory: 278.2M (peak: 300.8M)
          CPU: 18.676s
         CGroup: /system.slice/jenkins.service
                   └─6273 /usr/bin/java -Djava.awt.headless=true -jar /usr/share/java/jenkins.war --webroot=/var/cache/jenkins/war --httpPort=8080
```

Jenkins portal on webpage



Tested connectivity from Jenkins to App-server (AWS) (IP:44.204.190.114)

```
ubuntu@ip-10-0-2-237:~/.ssh$ sudo su - jenkins
jenkins@ip-10-0-2-237:~$ ssh -i ~/.ssh/dr-keypair.pem ubuntu@44.204.190.114 "echo AWS OK"
The authenticity of host '44.204.190.114 (44.204.190.114)' can't be established.
ED25519 key fingerprint is SHA256:JDa17pNWRLr9vsWjgl+ViCQi4xQGYwhtJtQyVx4DkSM.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '44.204.190.114' (ED25519) to the list of known hosts.
AWS OK
jenkins@ip-10-0-2-237:~$
```

Tested connectivity from Jenkins to App-server (Azure) (IP:20.121.42.105)

```
jenkins@ip-10-0-2-237:~$ ssh -i ~/.ssh/azurekey.pem azureuser@20.121.42.105 "echo AZURE OK"
The authenticity of host '20.121.42.105 (20.121.42.105)' can't be established.
ED25519 key fingerprint is SHA256:E4Uy+RaOtTMo2mDunyA24xrxxcJ82Rz00dg1SzWz8/4.
This key is not known by any other names.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '20.121.42.105' (ED25519) to the list of known hosts.
AZURE OK
jenkins@ip-10-0-2-237:~$
```

Created 2 separate index file for aws, azure server and Jenkins files in github repo

The screenshot shows a GitHub repository page for 'upgrade_project'. The repository has 4 commits:

- shivu9900 Update index-aws.html (aa886c8 · 2 minutes ago)
- Jenkinsfile Create Jenkinsfile (4 minutes ago)
- shivu9900 Update index-aws.html (2 minutes ago)
- index-aws.html Create index-aws.html (9 minutes ago)

The repository has 0 stars, 0 forks, and 0 releases.

Jenkins file

```
pipeline {
    agent any

    environment {
        AWS_KEY = "/var/lib/jenkins/.ssh/dr-keypair.pem"
        AZURE_KEY = "/var/lib/jenkins/.ssh/azurekey.pem"
        AWS_USER = "ubuntu"
        AZURE_USER = "azureuser"
        AWS_HOST = "44.204.190.114"
        AZURE_HOST = "20.121.42.105"
    }

    stages {
        stage('Pull Latest Files') {
            steps {
                echo "Pulled Latest HTML from GitHub"
            }
        }

        stage('Deploy to AWS') {
            steps {
                sh """
                    ssh -o StrictHostKeyChecking=no -i \$AWS_KEY
                    \$AWS_USER@\$AWS_HOST \
                    "sudo mv /var/www/html/index.html
                    /var/www/html/index.html.bak || true"

                    scp -o StrictHostKeyChecking=no -i \$AWS_KEY index-
aws.html \$AWS_USER@\$AWS_HOST:/tmp/index.html

                    ssh -i \$AWS_KEY \$AWS_USER@\$AWS_HOST \
                    "sudo mv /tmp/index.html /var/www/html/index.html && sudo
                    systemctl restart nginx"
                """
            }
        }

        stage('Deploy to Azure') {
            steps {
                sh """

```

```

        ssh -o StrictHostKeyChecking=no -i \$AZURE_KEY
\$AZURE_USER@\$AZURE_HOST \
        "sudo mv /var/www/html/index.html
/var/www/html/index.html.bak || true"

        scp -o StrictHostKeyChecking=no -i \$AZURE_KEY index-
azure.html \$AZURE_USER@\$AZURE_HOST:/tmp/index.html

        ssh -i \$AZURE_KEY \$AZURE_USER@\$AZURE_HOST \
        "sudo mv /tmp/index.html /var/www/html/index.html && sudo
systemctl restart nginx"
"""

    }

}

post {
    success {
        echo "Deployment Successful!"
    }
    failure {
        echo "Deployment Failed!"
    }
}
}

```

App Server AWS index file code:



The screenshot shows a GitHub commit page for the file `index-aws.html`. The commit was made by `shivu9900` at `aa886c8 · 6 minutes ago`. The commit message is `Update index-aws.html`. The commit history shows a single line of code:

```

1     <h1>Welcome to AWS - v1 from jenkins deployment</h1>

```

App Server Azure index file code:

The screenshot shows a GitHub repository page for 'upgrade_project'. The file 'index-azure.html' is displayed. The code content is as follows:

```
1     <h1>Welcome to Azure - v1 from Jenkins Deployment</h1>
```

Jenkins build console output:

The screenshot shows the Jenkins Pipeline console output for build #1. The log details the steps taken during the build process:

```
Started by user Shivakumara n d
Obtained Jenkinsfile from git https://github.com/shivu9900/upgrade_project.git
[Pipeline] Start of Pipeline
[Pipeline] node
Running on Jenkins in /var/lib/jenkins/workspace/MultiCloud-Deployment
[Pipeline] {
[Pipeline] stage
[Pipeline] {
  (Declarative: Checkout SCM)
  [Pipeline] checkout
Selected Git installation does not exist. Using Default
The recommended git tool is: NONE
No credentials specified
Cloning the remote Git repository
Cloning repository https://github.com/shivu9900/upgrade_project.git
> git init /var/lib/jenkins/workspace/MultiCloud-Deployment # timeout=10
Fetching upstream changes from https://github.com/shivu9900/upgrade_project.git
> git --version # timeout=10
> git --version # 'git version 2.43.0'
> git fetch --tags --force --progress -- https://github.com/shivu9900/upgrade_project.git
```



The screenshot shows the Jenkins console output for a job named "MultiCloud-Deployment". The log entries are as follows:

```
/var/www/html/index.html && sudo systemctl restart nginx
[Pipeline]
[Pipeline] // stage
[Pipeline] stage
[Pipeline] { (Declarative: Post Actions)
[Pipeline] echo
Deployment Successful!
[Pipeline]
[Pipeline] // stage
[Pipeline]
[Pipeline] // withEnv
[Pipeline]
[Pipeline] // withEnv
[Pipeline]
[Pipeline] // node
[Pipeline] End of Pipeline
Finished: SUCCESS
```

App-server (AWS) (IP:44.204.190.114) website access from html



App-server (Azure) (IP:20.121.42.105) website access from html



Task 5: Traffic Management Using AWS Route 53

Created hosted zone upgrad.com in AWS route 53

Route 53 > Hosted zones > upgrad.com

upgrad.com was successfully created.
Now you can create records in the hosted zone to specify how you want Route 53 to route traffic for your domain.

Public upgrad.com Info Delete zone Test record Configure query logging Edit hosted zone

Hosted zone details

Records (2) DNSSEC signing Hosted zone tags (0)

Records (2) Info

Record ...	Type	Routing ...	Differ...	Alias	Value/Route traffic to	TTL (s...)	Health ...	Evalu...	Reco...
upgrad.com	NS	Simple	-	No	ns-1969.awsdns-54.co.uk. ns-1011.awsdns-62.net. ns-1428.awsdns-50.org. ns-83.awsdns-10.com.	172800	-	-	-
upgrad.com	SOA	Simple	-	No	ns-1969.awsdns-54.co.uk. a...	900	-	-	-

Created 2 records for app server aws and app server azure respectively

Route 53 > Hosted zones > upgrad.com

Hosted zone details

Records (4) DNSSEC signing Hosted zone tags (0)

Records (4) Info

Record ...	Type	Routing ...	Differ...	Alias	Value/Route traffic to	TTL (s...)	Health ...	Evalu...	Reco...
upgrad.com	NS	Simple	-	No	ns-1969.awsdns-54.co.uk. ns-1011.awsdns-62.net. ns-1428.awsdns-50.org. ns-83.awsdns-10.com.	172800	-	-	-
upgrad.com	SOA	Simple	-	No	ns-1969.awsdns-54.co.uk. a...	900	-	-	-
app.upgrad.com	A	Failover	Primary	No	44.204.190.114	300	5d5244c4...	-	aws-p
app.upgrad.com	A	Failover	Secondary	No	20.121.42.105	300	-	-	azure

Traffic direct is tested using Dummy Hosted Zone in Route 53 as upgrad.com is already registered and we can't reuse the same in public domain.

Route 53 directs traffic to the AWS App Machine **App-server (AWS)**
(IP:44.204.190.114) when it is healthy

Response returned by Route 53
Response from Route 53 based on the following options.

Hosted zone
upgrad.com

Record name
app

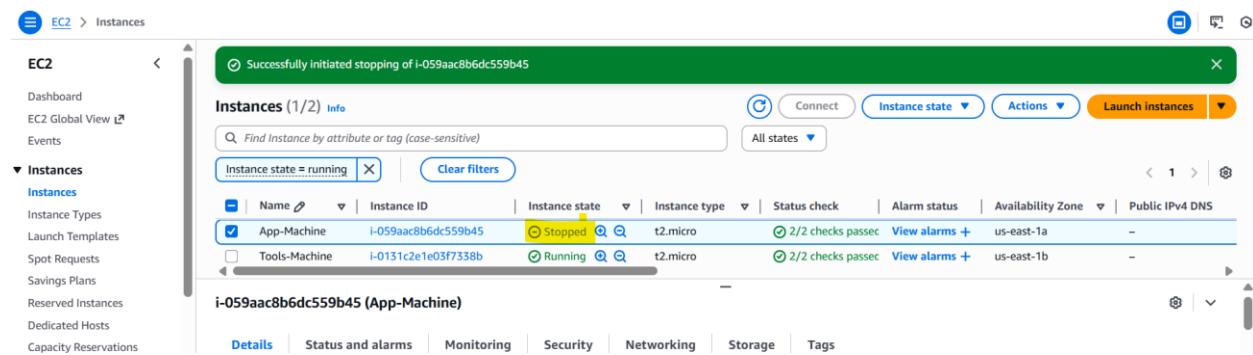
Record type
A

DNS response code
⌚ No Error

Protocol
UDP

Response returned by Route 53
44.204.190.114

Stopped the AWS app machine



The screenshot shows the AWS EC2 Instances page. A green notification bar at the top indicates "Successfully initiated stopping of i-059aac8b6dc559b45". The main table displays two instances:

Name	Instance ID	Instance state	Instance type	Status check	Alarm status	Availability Zone	Public IPv4 DNS
App-Machine	i-059aac8b6dc559b45	Stopped	t2.micro	2/2 checks passed	View alarms +	us-east-1a	-
Tools-Machine	i-0131c2e1e03f7338b	Running	t2.micro	2/2 checks passed	View alarms +	us-east-1b	-

Below the table, a detailed view for the 'App-Machine' instance is shown with tabs for Details, Status and alarms, Monitoring, Security, Networking, Storage, and Tags.

Route 53 redirects traffic to the Azure VM's public IP App-server (Azure) (IP:20.121.42.105) as AWS app machine is stopped

Response returned by Route 53
Response from Route 53 based on the following options.

Hosted zone
upgrad.com

Record name
app

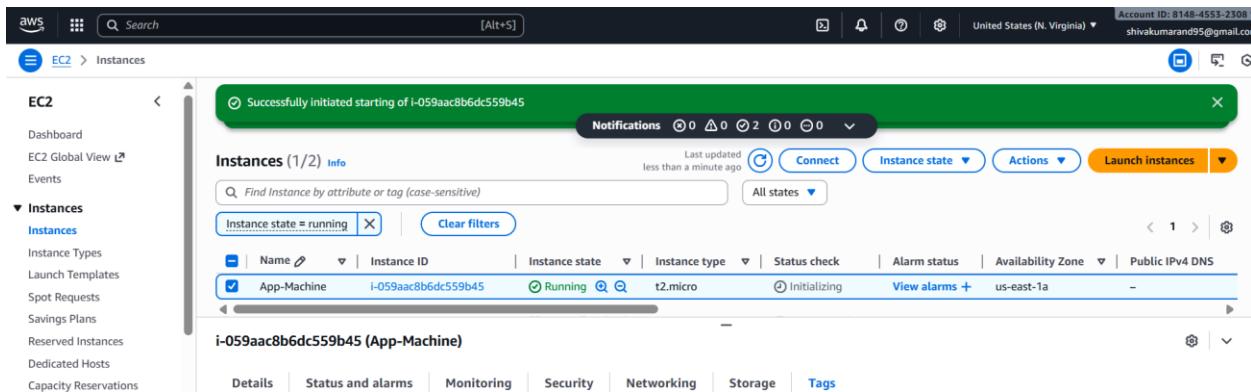
Record type
A

DNS response code
No Error

Protocol
UDP

Response returned by Route 53
20.121.42.105

Restarted the AWS App machine



The screenshot shows the AWS EC2 Instances page. A green notification bar at the top left says "Successfully initiated starting of i-059aac8b6dc559b45". The main table has one row:

Name	Instance ID	Instance state	Instance type	Status check	Alarm status	Availability Zone	Public IPv4 DNS
App-Machine	i-059aac8b6dc559b45	Running	t2.micro	Initializing	View alarms	us-east-1a	-

Route 53 redirects traffic to the AWS VM's public IP as AWS app machine App-server (AWS) (IP:44.204.190.114) is restarted again

Response returned by Route 53

Response from Route 53 based on the following options.

Hosted zone
upgrad.com

Record name
app

Record type
A

DNS response code
 ⓘ No Error

Protocol
UDP

Response returned by Route 53
44.204.190.114
