# AZURE : 3-TIER-ARCHITECTURE PROJECT :

*"Authored and implemented by"*

*Bindurachamalla.*

## 1. INTRODUCTION:

**3-Tier Architecture** is a standard way of designing applications by separating them into **three logical layers**, each with a clear responsibility. This improves **scalability, security, maintainability, and performance**.

➢ **WEB TIER (CLIENT LAYER**)

- Handles the user interface
- Displays data to users
- Collects user input

Examples:

- Web browser (HTML, CSS, JavaScript)
- Mobile app UI
- Frontend frameworks (React, Angular)

➢ **APPLICATION TIER (BUSINESS LOGIC LAYER)**

- Processes user request
- Applies business rule
- Acts as a bridge between UI and database

Examples :

- Java Servlets
- Spring Boot application
- REST APIs

➢ **DATA TIER (DATABASE LAYER)**

- Stores and retrieves data
- Ensures data consistency and security

Examples :

- MySQL
- PostgreSQL

## 2. OBJECTIVES OF 3-TIER ARCHITECTURE :

1. Separation of presentation, business logic, and data
2. Easy maintenance and updates
3. Improved security
4. Better scalability
5. Reusability of components
6. Improved performance

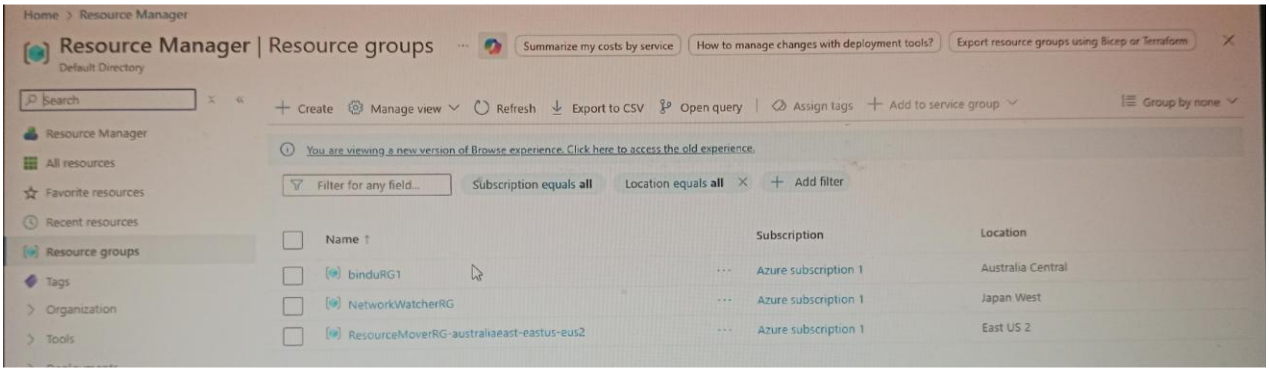
## 3. TOOLS USED FOR THE PROJECT :

- Microsoft Azure Services: VNets, Subnets, NSGs, VMs
- Web Server: NGINX
- Application Server: Apache Tomcat
- Database: MySQL
- Networking: VNet Peering, Network Security Groups
- Automation: Azure CLI, Bash Scripting

## 4. IMPLEMENTATION OF 3 TIER ARCHITECTURE ON AZURE IMPLEMENTATION STEPS :

### 4.1 : RESOURCE GROUP CREATION:

- In the Azure portal, Search for Resources group
- On the Resource group page, click on Create New.
- Now create a RG
- RG name : **binduRG1** in Azure subscription1
- Location : Australia Central



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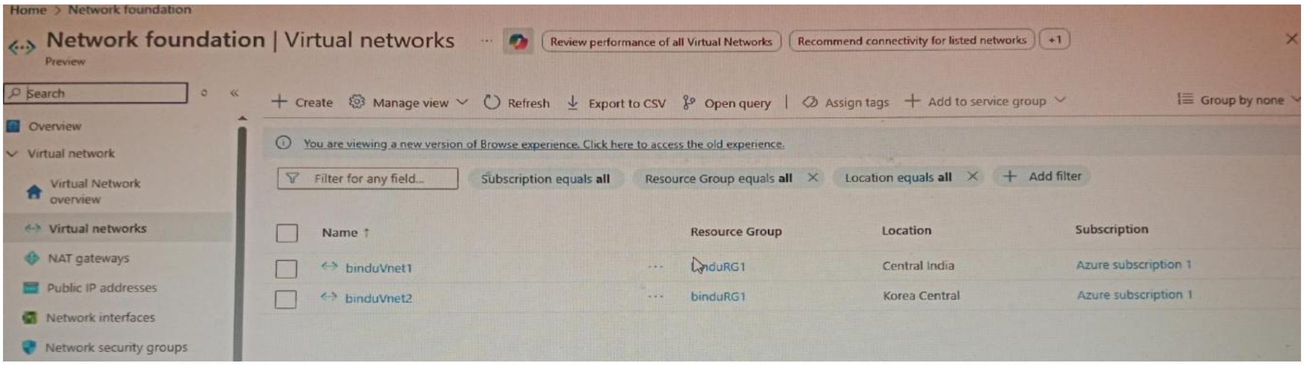
| Name ↑ | Subscription | Location |
|---|---|---|
| binduRG1 | Azure subscription 1 | Australia Central |
| NetworkWatcherRG | Azure subscription 1 | Japan West |
| ResourceMoverRG-australiaeast-eastus-eus2 | Azure subscription 1 | East US 2 |

Image 1:Resource Group

### 4.2 : VIRTUAL NETWORKS CONFIGURATION :

4.2.1 VIRTUAL NETWORK 1 (PRIMARY NETWORK)

- In the portal, Search for Virtual Network.
- On the Virtual networks page, click on Create New.
- On the Basic Tabs, provide details of Subscription, resource group and Virtual network
- Virtual Network Name : **binduVnet1**
- Location : **Central India** region and click on IP address.



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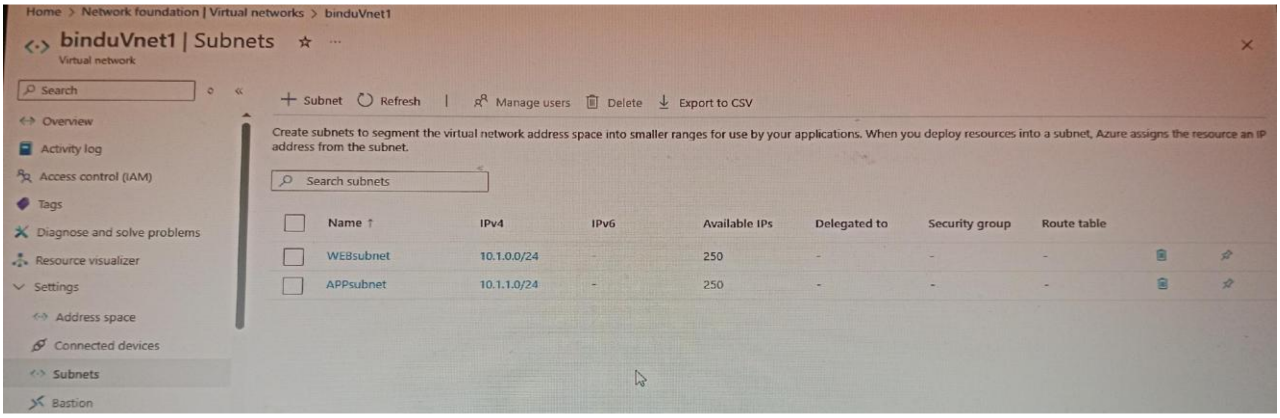
| Name ↑ | Resource Group | Location | Subscription |
|---|---|---|---|
| binduVnet1 | binduRG1 | Central India | Azure subscription 1 |
| binduVnet2 | binduRG1 | Korea Central | Azure subscription 1 |

Image 2 : Two Virtual Networks in different regions

- Provide IP address and Create 2 Subnets.
- Subnet 1 Name **: WEBsubnet**
- Subnet 2 Name : **APPsubnet** and click on Create.
- Select Next to proceed to the Security tab.
- Enter Ip address range and subnet range.



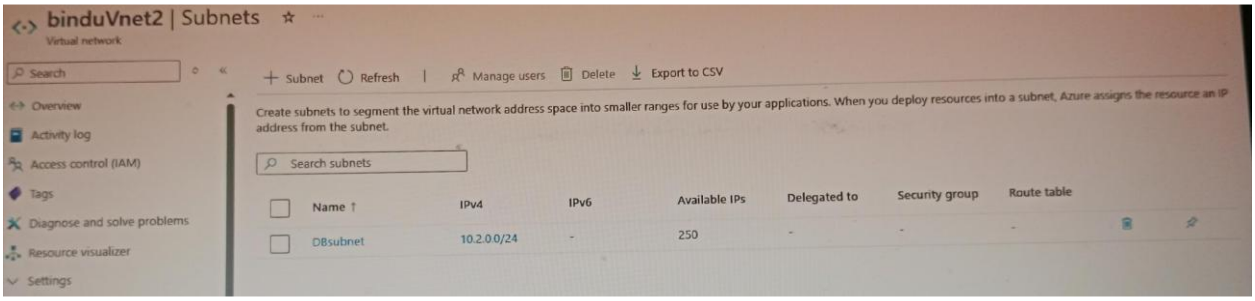
Create subnets to segment the virtual network address space into smaller ranges for use by your applications. When you deploy resources into a subnet, Azure assigns the resource an IP address from the subnet.

| Name ↑ | IPv4 | IPv6 | Available IPs | Delegated to | Security group | Route table |
|---|---|---|---|---|---|---|
| WEBsubnet | 10.1.0.0/24 | - | 250 | - | - | - |
| APPsubnet | 10.1.1.0/24 | - | 250 | - | - | - |

Image 3 : Two Subnets in binduVnet1

4.2.2 : VIRTUAL NETWORK 2 (DATABASE NETWORK)

- Create Virtual Network 2
- Name : **binduVent2**
- Location : **Korea Central**
- Now click on ip address and provide ip address.
- Now Create Subnet 3
- Name : **DBsubnet.**



Create subnets to segment the virtual network address space into smaller ranges for use by your applications. When you deploy resources into a subnet, Azure assigns the resource an IP address from the subnet.

| Name ↑ | IPv4 | IPv6 | Available IPs | Delegated to | Security group | Route table |
|---|---|---|---|---|---|---|
| DBsubnet | 10.2.0.0/24 | - | 250 | - | - | - |

Image 4 : one Subnet in binduVnet2

## 4.3 : VIRTUAL MACHINES CREATION :

### 4.3.1 : VIRTUAL MACHINE 1

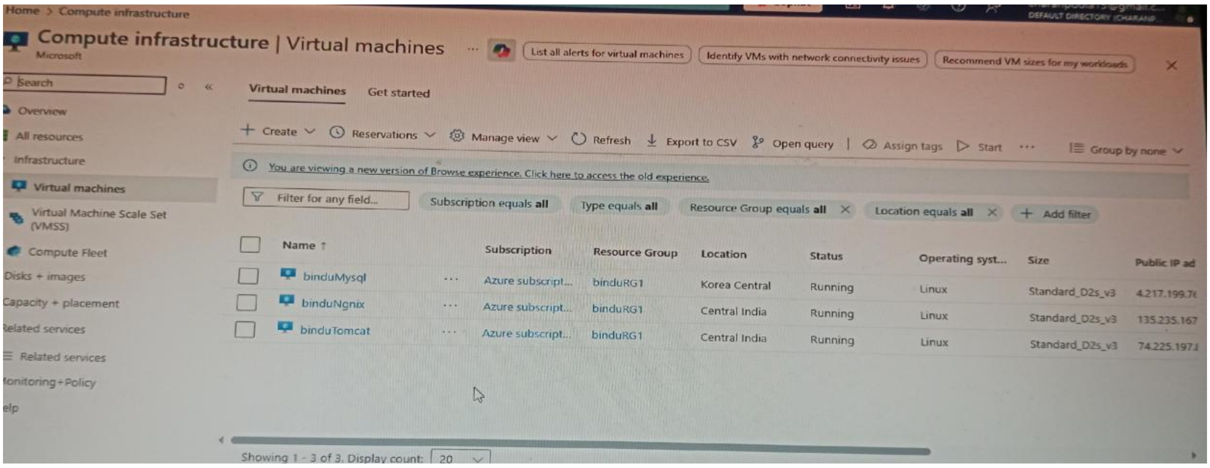
- In Virtual Network open **binduVnet1** ,open subnets and select **WEBsubnet** and search for Virtual Machine.
- Now create a **Virtual Machine1**
- Virtual Machine Name: **binduNginx .**
- Use default options in the Disk tab, then move to Networking tab select WEBsubnet and select basic in NIC.
- Now go to management tab and select advanced and give custom data and enter commands :
  #!/bin/bash
  Sudo su
  apt update
  apt install nginx -y and create .

### 4.3.2 : VIRTUAL MACHINE 2

- Now go back and select **APPsubnet** and Create **Virtual Machine2** .
- Virtual Machine Name : **binduTomcat**
- In Networking select APPsubnet , give basic for NIC.

### 4.3.3 : VIRTUAL MACHINE 3

- Now open Virtual Network binduVnet2 and in subnets select **DBsubnet.**
- Create **Virtual Machine3**
- Virtual Machine Name : **binduMysql.**



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| Name ↑ | Subscription | Resource Group | Location | Status | Operating syst... | Size | Public IP ad |
|---|---|---|---|---|---|---|---|
| binduMysql | Azure subscript... | binduRG1 | Korea Central | Running | Linux | Standard_D2s_v3 | 4.217.199.7 |
| binduNgnix | Azure subscript... | binduRG1 | Central India | Running | Linux | Standard_D2s_v3 | 135.235.167 |
| binduTomcat | Azure subscript... | binduRG1 | Central India | Running | Linux | Standard_D2s_v3 | 74.225.197.1 |

Image 5 : 3 Virtual Machines

## 4.4 : VNET PEERING CONFIGURATION :

- In azure we can create a peering connection between two virtual networks that enables the private communication between vnets.
- Peering connection can be created b/w any two azure vnets where address spaces do not conflict.

➢ **Configuring VNet Peering between VNET1_ binduVnet1 and VNET2_binduVnet2 .**

4.4.1 : CREATE PEERING FROM VNET1 TO VNET2

- Creating peering: vnet1-to-vnet2
- Name : vnet1-to-vnet2
- Resource-group : RG_NAME
- Vnet-name :VNET1_NAME
- Allow-vnet-access
- Allow-forwarded-traffic
- Now Add it .

4.4.2 : CREATE PEERING FROM VNET2 TO VNET1

- Creating peering: vnet2-to-vnet1
- Name : vnet2-to-vnet1
- Resource-group : RG_NAME
- Vnet-name : VNET2_NAME
- Allow-vnet-access
- Allow-forwarded-traffic and add

## 5. NETWORK SECURITY GROUPS :

### 5.1: NSG for Web Tier (nginx-vm) :

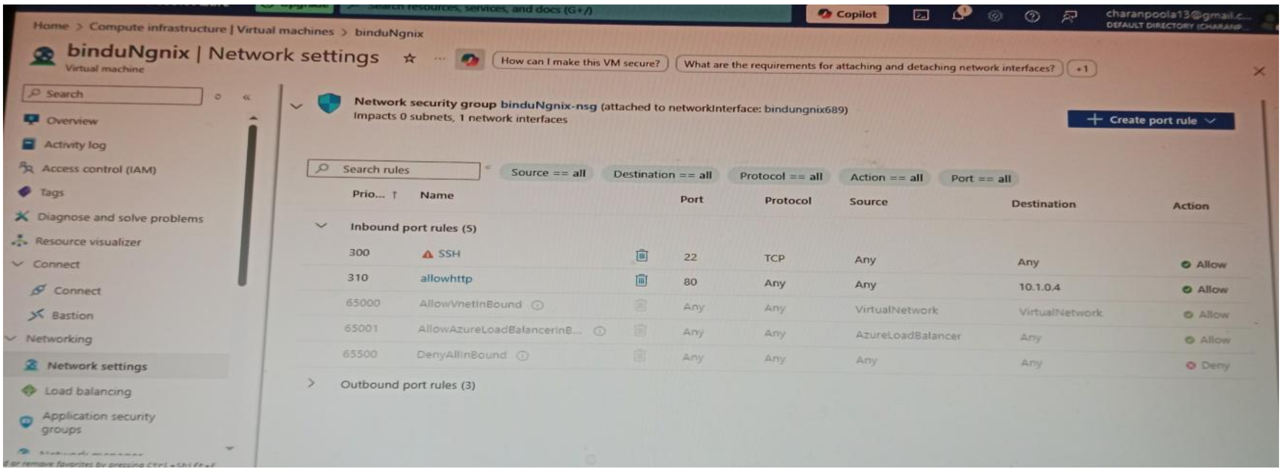
➢ Inbound Rules for Web Tier:

➢ RULE 1:

- Source: Any
- Destination: webserver Ip address
- Destination port: 80
- Action: allow

➢ RULE 2 :

- Source: webserver Ip address
- Destination: appserver Ip address
- Destination port: 8080
- Action: allow



Network security group binduNgnix-nsg (attached to networkInterface: bindungnix689)
Impacts 0 subnets, 1 network interfaces

| Prio... | Name | Port | Protocol | Source | Destination | Action |
|---|---|---|---|---|---|---|
| Inbound port rules (5) | | | | | | |
| 300 | SSH | 22 | TCP | Any | Any | Allow |
| 310 | allowhttp | 80 | Any | Any | 10.1.0.4 | Allow |
| 65000 | AllowVnetInBound | Any | Any | VirtualNetwork | VirtualNetwork | Allow |
| 65001 | AllowAzureLoadBalancerInB... | Any | Any | AzureLoadBalancer | Any | Allow |
| 65500 | DenyAllInBound | Any | Any | Any | Any | Deny |

Outbound port rules (3)

Image 6 : Inbound port rules for web server

### 5.2 : NSG for App Tier (Tomcat-vm) :

➢ Inbound Rules for App Tier :

➢ RULE 1 :

- Source: webserver Ip address
- Destination: Appserver Ip address
- Destination port: 8080
- Action: allow

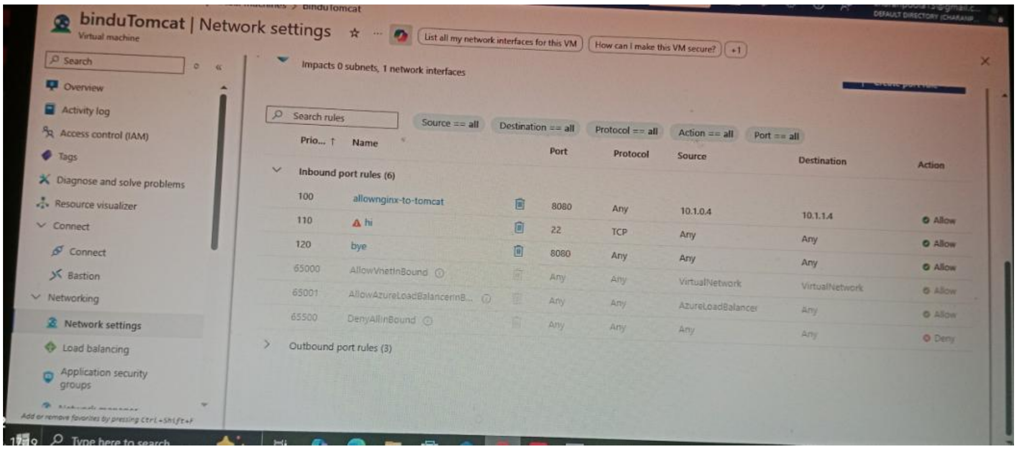
The above inbound rules are used for connecting app to web

➢ RULE 2 :

- Source: Any
- Destination: Appserver Ip address
- Destination port: 8080
- Action: allow

➢ RULE 3 :

- Source: Appserver IP address
- Destination: dB server IP address
- Destination port: 3306
- Action: allow



binduTomcat | Network settings

Virtual machine

Impacts 0 subnets, 1 network interfaces

| Prio... | Name | Port | Protocol | Source | Destination | Action |
|---|---|---|---|---|---|---|
| Inbound port rules (6) | | | | | | |
| 100 | allownginx-to-tomcat | 8080 | Any | 10.1.0.4 | 10.1.1.4 | Allow |
| 110 | hi | 22 | TCP | Any | Any | Allow |
| 120 | bye | 8080 | Any | Any | Any | Allow |
| 65000 | AllowVnetInBound | Any | Any | VirtualNetwork | VirtualNetwork | Allow |
| 65001 | AllowAzureLoadBalancerInB... | Any | Any | AzureLoadBalancer | Any | Allow |
| 65500 | DenyAllInBound | Any | Any | Any | Any | Deny |

Outbound port rules (3)

Image 7 : Inbound port rules for App server

### 5.3 : NSG for Db Tier (Mysql-vm) :

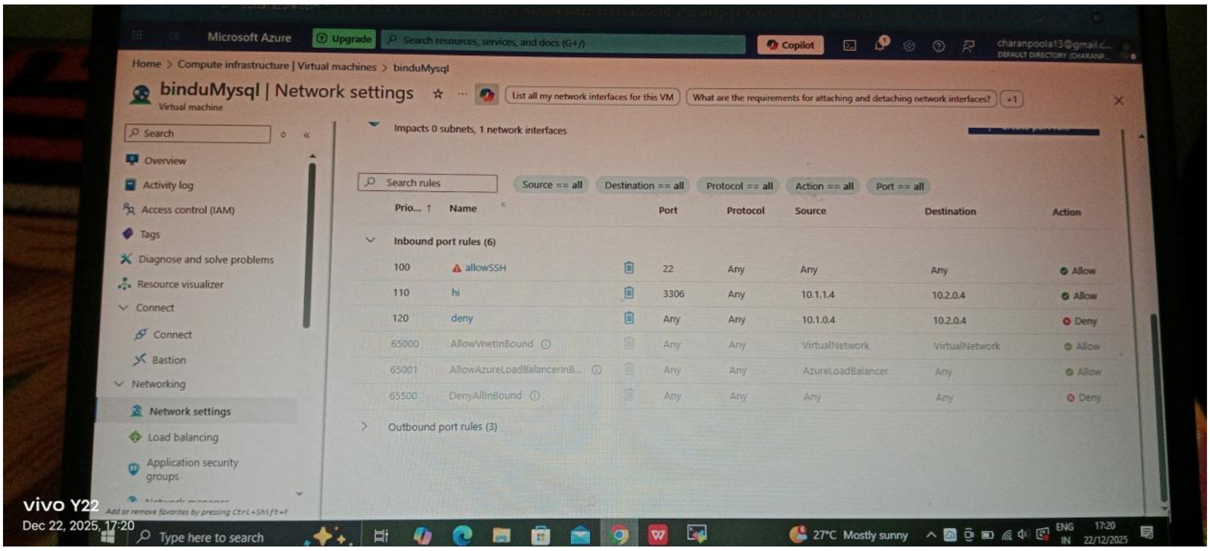
➢ Inbound Rules for App Tier :

➢ RULE 1 :

- Source: Appserver IP address
- Destination: Database server IP address
- Destination port: 3306
- Action: allow

➢ RULE 2 :

- Source: webserver IP address
- Destination: Database server IP address
- Destination port: Any
- Action: deny



binduMysql | Network settings

Virtual machine

Impacts 0 subnets, 1 network interfaces

| Prio... | Name | Port | Protocol | Source | Destination | Action |
|---|---|---|---|---|---|---|
| Inbound port rules (6) | | | | | | |
| 100 | allowSSH | 22 | Any | Any | Any | Allow |
| 110 | hi | 3306 | Any | 10.1.1.4 | 10.2.0.4 | Allow |
| 120 | deny | Any | Any | 10.1.0.4 | 10.2.0.4 | Deny |
| 65000 | AllowVnetInBound | Any | Any | VirtualNetwork | VirtualNetwork | Allow |
| 65001 | AllowAzureLoadBalancerInB... | Any | Any | AzureLoadBalancer | Any | Allow |
| 65500 | DenyAllInBound | Any | Any | Any | Any | Deny |

Outbound port rules (3)

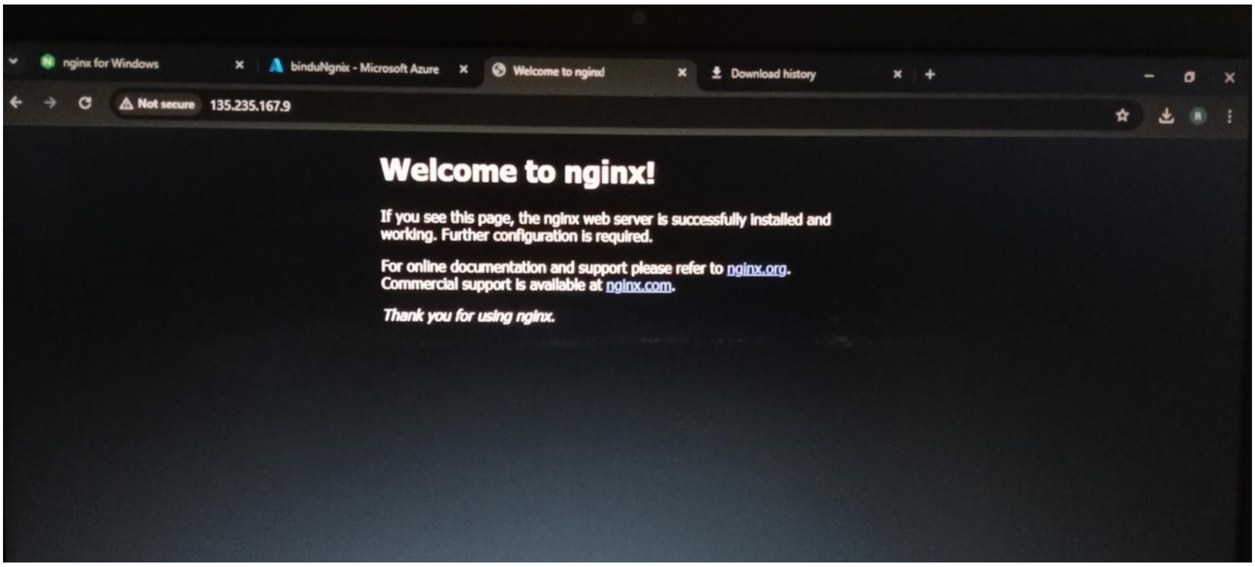
Image 8 :Inbound port rules for DB server

## 6. SOFTWARE INSTALLATION & CONFIGURATION :

### 6.1 : NGINX Installation in WEB Server :

- While creating **binduNgnix** Virtual Machine select Management Tab and enter the custom data in Advanced Tab .
- Commands used to instal Nginx :
  #!/bin/bash
  Sudo su
  Apt update
  Apt install Nginx -y

- Now copy the public IP address of **binduNginx** Virtual Machine and paste it in mobaxtream. In New sessions go to SSH and paste the ip address and give the username and password .
- Now the Nginx machine is installed in WebVM .
- Now in Google browse the public ip address of Nginx
- Now we can see the Nginx page as shown in the image .



**Welcome to nginx!**

If you see this page, the nginx web server is successfully installed and working. Further configuration is required.

For online documentation and support please refer to nginx.org. Commercial support is available at nginx.com.

*Thank you for using nginx.*

Image 9 : Nginx page on Google

### 6.2 : TOMCAT installation in APP Server :

- To install Apache Tomcat in APP Virtual Machine in **binduTomcat ,**follow these steps:
- To switch from a normal user ($ prompt) to the root user (# prompt) in Ubuntu, use any of the following :

➢ commands:

- sudo su

a. This switches you to the root user.
b. The prompt will change from $ to #.

➢ Update System Packages:

- apt update

➢ Install Java

- Tomcat requires Java. Install OpenJDK:
- apt install default-jdk -y

➢ Verify the installation:

- java -version

➢ Download Tomcat :

- Go to the Apache Tomcat official website and get the latest version.

Run:

➢ wget https://dlcdn.apache.org/tomcat/tomcat-10/v10.1.18/bin/apache-tomcat-10.1.18.tar.gz

➢ Extract and Configure Tomcat

- tar -xvzf apache-tomcat-10.1.18.tar.gz
- ls
- mv apache-tomcat-10.1.18 tomcat
- ls

To start Apache Tomcat manually from the bin directory, follow these steps:

➢ Navigate to the Tomcat Directory

- cd /tomcat/bin

➢ Start Tomcat

Run the startup script: (./ is to execute a command)

- ./startup.sh

➢ Access Tomcat

Open your browser and go to:
http://your_server_ip:8080

➢ Editing context.xml for Host Manager:

The Valve element in Tomcat's context.xml file is used for access control and request filtering. Specifically, the RemoteAddrValve restricts access based on the client's IP address.

➢ How It Works

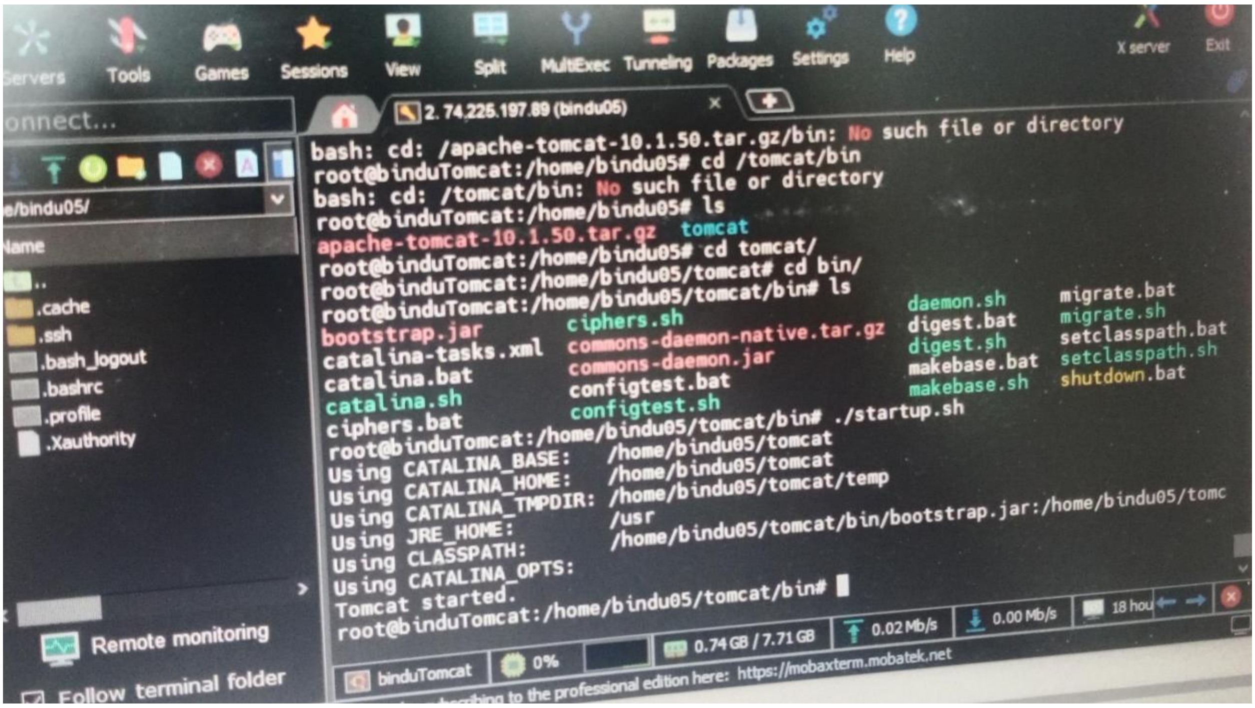
- Restricting Access
- Allowing Specific Networks
- Allowing All IPs (Not Recommended)

➢ Save and restart Tomcat:

- sudo systemctl restart tomcat
- Now, you can access Tomcat Manager at:

http://localhost:8080/manager/html

- Use the configured username and password.



```
bash: cd: /apache-tomcat-10.1.50.tar.gz/bin: No such file or directory
root@binduTomcat:/home/bindu05# cd /tomcat/bin
bash: cd: /tomcat/bin: No such file or directory
root@binduTomcat:/home/bindu05# ls
apache-tomcat-10.1.50.tar.gz  tomcat
root@binduTomcat:/home/bindu05# cd tomcat/
root@binduTomcat:/home/bindu05/tomcat# cd bin/
root@binduTomcat:/home/bindu05/tomcat/bin# ls
bootstrap.jar        ciphers.sh                     daemon.sh      migrate.bat
catalina-tasks.xml   commons-daemon-native.tar.gz   digest.bat     migrate.sh
catalina.bat         commons-daemon.jar             digest.sh      setclasspath.bat
catalina.sh          configtest.bat                 makebase.bat   setclasspath.sh
ciphers.bat          configtest.sh                  makebase.sh    shutdown.bat
root@binduTomcat:/home/bindu05/tomcat/bin# ./startup.sh
Using CATALINA_BASE:   /home/bindu05/tomcat
Using CATALINA_HOME:   /home/bindu05/tomcat
Using CATALINA_TMPDIR: /home/bindu05/tomcat/temp
Using JRE_HOME:        /usr
Using CLASSPATH:       /home/bindu05/tomcat/bin/bootstrap.jar:/home/bindu05/tomc
Using CATALINA_OPTS:
Tomcat started.
root@binduTomcat:/home/bindu05/tomcat/bin#
```

Image 10 : Installation of Tomcat in App server

- ➢ **Checking the connection between the WEBand APP server :**

- Now open Mobaxtream and go to New sessions and in SSH paste the public IP address of Web VM **binduNginx** .
- Give username and password .
- Now enter the telnet command to check the connection between WebVM and App VM
- Enter Telnet < IP address> of App VM **binduTomcat** with port 8080
- The result shown as  Web VM and App VM are connected .

### 6.3 :MYSQL installation in DB Server :

- To install MYSQL on Ubuntu, follow these steps:
- To switch from a normal user ($ prompt) to the root user (# prompt) in Ubuntu, use any of the following
- ➢ commands:
- sudo su
- ➢ Update System Packages
- apt update

➢ Run the following command to install MySQL:

- apt install mysql-server –y

➢ To improve security, run the following command:

- mysql_secure_installation

➢ Edit the MySQL configuration file using a text editor:

- nano /etc/mysql/mysql.conf.d/mysqld.cnf
- bind-address = 0.0.0.0

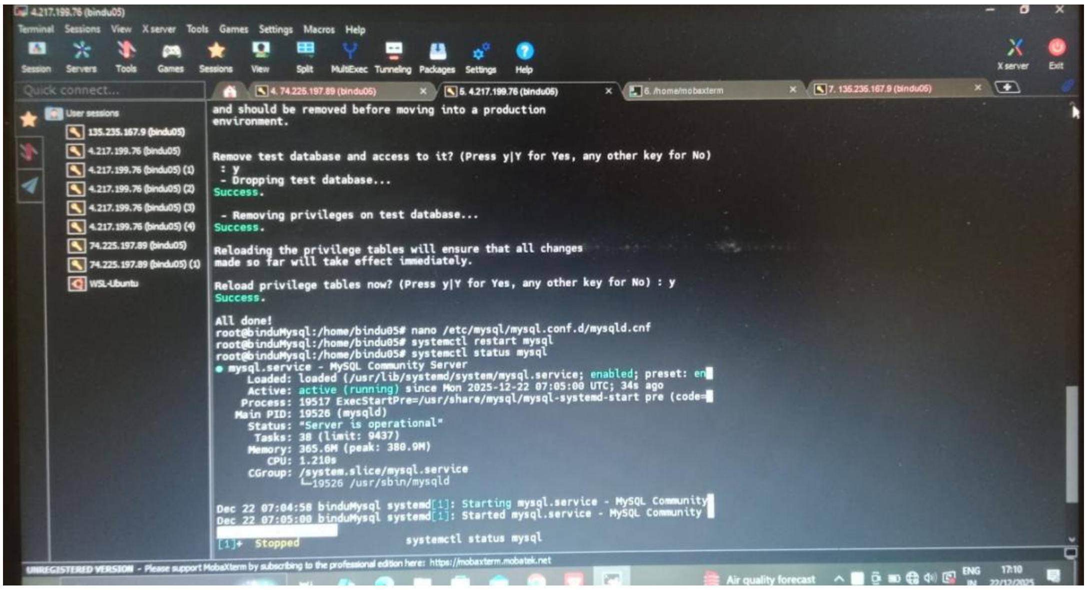
- Save and exit (CTRL + X, then Y, then Enter).

➢ To restart MySQL:

- systemctl restart mysql

➢ Check if MySQL is running:

- systemctl status mysql



```
and should be removed before moving into a production
environment.


Remove test database and access to it? (Press y|Y for Yes, any other key for No)
 : y
 - Dropping test database...
Success.

 - Removing privileges on test database...
Success.

Reloading the privilege tables will ensure that all changes
made so far will take effect immediately.

Reload privilege tables now? (Press y|Y for Yes, any other key for No) : y
Success.

All done!
root@binduMysql:/home/bindu05# nano /etc/mysql/mysql.conf.d/mysqld.cnf
root@binduMysql:/home/bindu05# systemctl restart mysql
root@binduMysql:/home/bindu05# systemctl status mysql
● mysql.service - MySQL Community Server
     Loaded: loaded (/usr/lib/systemd/system/mysql.service; enabled; preset: en
     Active: active (running) since Mon 2025-12-22 07:05:00 UTC; 34s ago
    Process: 19517 ExecStartPre=/usr/share/mysql/mysql-systemd-start pre (code=
   Main PID: 19526 (mysqld)
     Status: "Server is operational"
      Tasks: 38 (limit: 9437)
     Memory: 365.6M (peak: 380.9M)
        CPU: 1.210s
     CGroup: /system.slice/mysql.service
             └─19526 /usr/sbin/mysqld

Dec 22 07:04:58 binduMysql systemd[1]: Starting mysql.service - MySQL Community
Dec 22 07:05:00 binduMysql systemd[1]: Started mysql.service - MySQL Community

[1]+  Stopped                 systemctl status mysql
```

4.217.199.76 (bindu05)
Terminal Sessions View X server Tools Games Settings Macros Help
Session Servers Tools Games Sessions View Split MultiExec Tunneling Packages Settings Help
X server Exit
Quick connect...
4. 74.225.197.89 (bindu05)
5. 4.217.199.76 (bindu05)
6. /home/mobaxterm
7. 135.236.167.9 (bindu05)
User sessions
135.235.167.9 (bindu05)
4.217.199.76 (bindu05)
4.217.199.76 (bindu05) (1)
4.217.199.76 (bindu05) (2)
4.217.199.76 (bindu05) (3)
4.217.199.76 (bindu05) (4)
74.225.197.89 (bindu05)
74.225.197.89 (bindu05) (1)
WSL-Ubuntu
UNREGISTERED VERSION - Please support MobaXterm by subscribing to the professional edition here: https://mobaxterm.mobatek.net
Air quality forecast
ENG
17:10

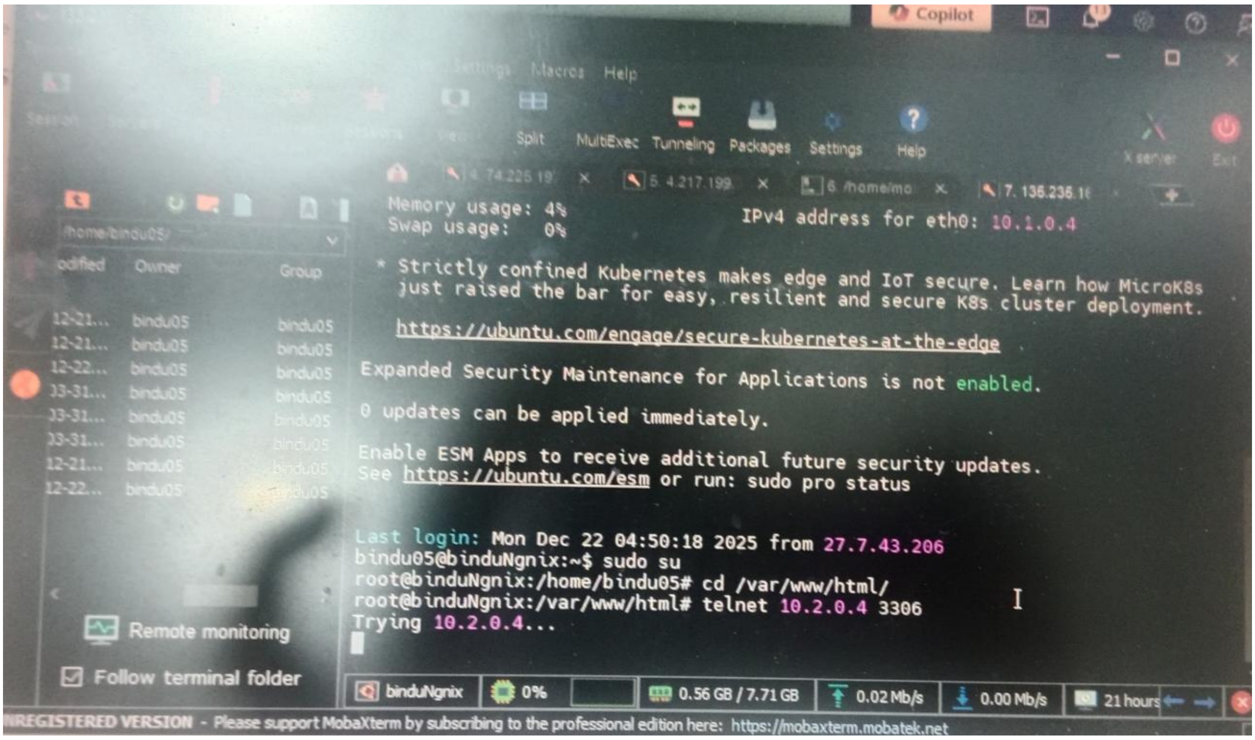
Image 11 : Installation of MySQL in DB server

➢ **Checking the connection between APP and DB server :**

- Now open Mobaxtream and go to New sessions and in SSH paste the public IP address of the App VM**.**
- Give ur username and password .
- Now enter the telnet command to check the connection between App VM and Db VM
- Enter telnet <IP address> of Db VM and port 3306
- The result shown as  DB VM and App VM  are connected on port 3306

➢ **Checking connection between WEB and DB server :**

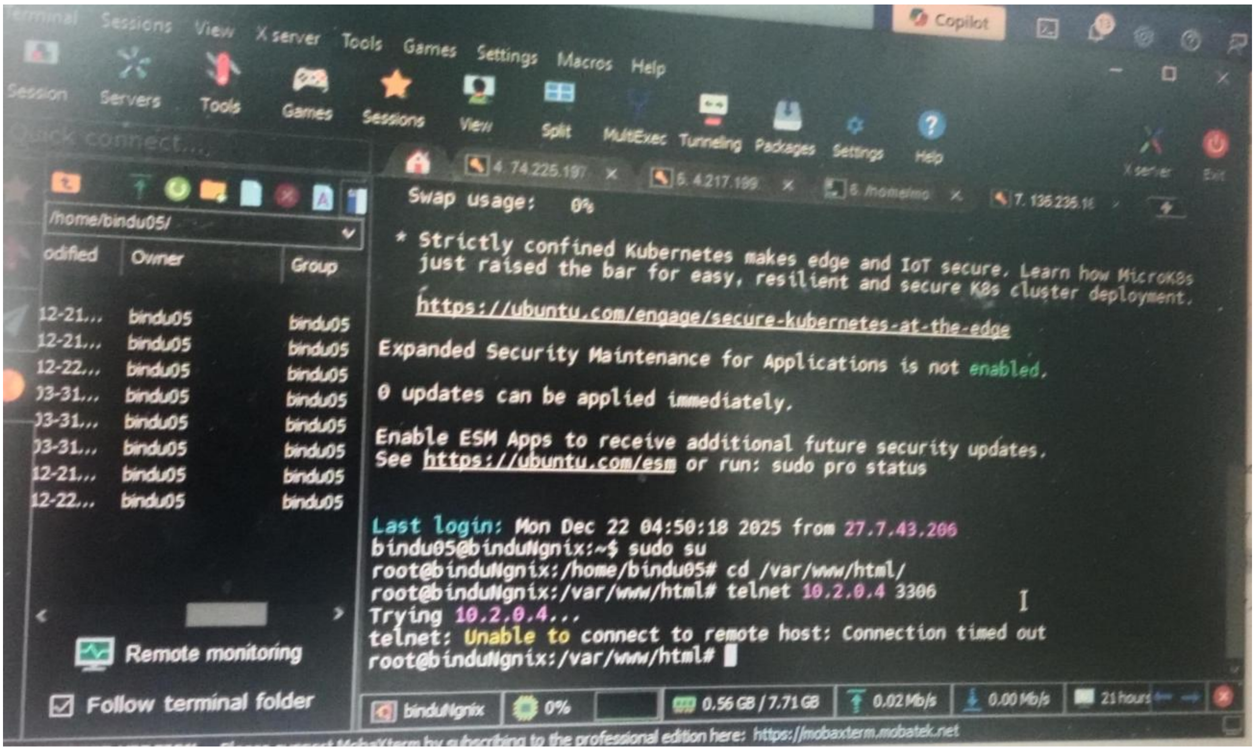
- Go to New sessions in mobaxtream, in SSH paste the public IP address of WebVM **binduNginx.**
- Enter username and password
- Now enter the commands :
  sudo su
  cd /var/www/html/
- Telnet <IP address> of Db VM and 3306
- The result is shown in below image 12 .



```
Memory usage: 4%                IPv4 address for eth0: 10.1.0.4
Swap usage:   0%

 * Strictly confined Kubernetes makes edge and IoT secure. Learn how MicroK8s
   just raised the bar for easy, resilient and secure K8s cluster deployment.

   https://ubuntu.com/engage/secure-kubernetes-at-the-edge

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


Last login: Mon Dec 22 04:50:18 2025 from 27.7.43.206
bindu05@binduNgnix:~$ sudo su
root@binduNgnix:/home/bindu05# cd /var/www/html/
root@binduNgnix:/var/www/html# telnet 10.2.0.4 3306
Trying 10.2.0.4...
```

Image 12 : checking connection between WEB and DB server

- The connection between the web server and Db server is denied on port 3306 because,  inbound rules We have added a rule to deny on port 3306
.



```
Swap usage:   0%

 * Strictly confined Kubernetes makes edge and IoT secure. Learn how MicroK8s
   just raised the bar for easy, resilient and secure K8s cluster deployment.

   https://ubuntu.com/engage/secure-kubernetes-at-the-edge

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


Last login: Mon Dec 22 04:50:18 2025 from 27.7.43.206
bindu05@binduNgnix:~$ sudo su
root@binduNgnix:/home/bindu05# cd /var/www/html/
root@binduNgnix:/var/www/html# telnet 10.2.0.4 3306
Trying 10.2.0.4...
telnet: Unable to connect to remote host: Connection timed out
root@binduNgnix:/var/www/html#
```

Image 13 : connection failed between WEB and DB server

## 7.**<u>PROJECT CONCLUSION:</u>**

- Throughout this comprehensive project, I successfully designed, implemented, and validated a production-ready 3-tier web application architecture on Microsoft Azure.
- The implementation of the 3-Tier Architecture successfully demonstrates the separation of an application into Web, Application, and Database layers.
- In this project, the Web Tier using Nginx acts as the client-facing layer.This tier serves as the first level of interaction between the user and the application while shielding internal components from direct access.
- The Application Tier implemented using Apache Tomcat serves as the core processing layer of the system. It is responsible for executing business logic, handling application workflows, managing communication between the Web Tier and the Database Tier.
- The Database Tier using MySQL provides a reliable and structured mechanism for data storage and retrieval. By isolating the database layer, sensitive data is protected from direct user access, ensuring better data security and integrity.