

# GCP Virtual Machine Implementation with Auto-Scaling and Security

## Assignment Report

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Computing - CSL7510

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# Introduction

This document provides a comprehensive guide to setting up a virtual machine environment in Google Cloud Platform with auto-scaling capabilities and robust security measures.

The implementation follows cloud best practices to ensure scalability, reliability, and security of the deployment.

## Step-by-Step Implementation

### Creating a VM Instance

#### 1. Navigate to Google Cloud Console

- Go to <https://console.cloud.google.com/> (<https://console.cloud.google.com/>)
- Select or create a project for your VM deployment

#### 2. Access Compute Engine

- From the navigation menu, select "Compute Engine" > "VM instances"
- Click "Create Instance"

#### 3. Configure the VM

- Name: `web-server-vm-template`
- Region and Zone: Select based on your latency requirements (e.g., `us-central1-a`)
- Machine Configuration:
  - Series: E2 (cost-effective)
  - Machine type: `e2-medium` (2 vCPU, 4 GB memory)

#### 4. Configure Boot Disk

- Operating System: Debian 11 (Bullseye)
- Boot disk type: Standard persistent disk (`pd-standard`)
- Size: 20 GB

#### 5. Configure Identity and API Access

- Service account: Select a service account with minimal required permissions
- Access scopes: Set to "Allow default access"

#### 6. Configure Firewall

- Allow HTTP traffic: Yes (for web server access)
- Allow HTTPS traffic: Yes (for secure web access)

#### 7. Advanced Options

- Management: Add startup script to install and configure web server software:

```
#!/bin/bash apt-get
update apt-get install -
y apache2 cat <<EOF >
/var/www/html/index.html
<html>
  <body>      <h1>Hello
from Google Cloud VM!</h1>
  <p>Server: $(hostname)</p>
</body>
</html>
EOF
```

## 8. Create the VM

- Click "Create" to provision the VM

## 9. Create a VM Instance Template

- Navigate to "Compute Engine" > "Instance templates"
  - Click "Create instance template"
  - Configure with the same settings as your VM
- Click "Create"

### Configuring Auto-Scaling Policies

## 1. Create a Managed Instance Group (MIG)

- Navigate to "Compute Engine" > "Instance groups"
  - Click "Create Instance Group"
  - Select "New managed instance group (stateless)"
  - Name: web-server-mig
  - Instance template: Select your created template
  - Location: Regional (recommended for high availability)
  - Region: Same as your VM template
- Minimum number of instances: 2  
Maximum number of instances: 10
- Click "Create"

## 2. Configure Auto-Scaling Policies

- From your MIG, click "Edit"
  - Under "Autoscaling", select "On: add and remove instances to the group"
- Autoscaling metrics:
- Select "CPU utilization"
  - Target CPU utilization: 70%
- Cool-down period: 60 seconds
- Click "Done" and "Save"

### 3. Configure Health Check

- Navigate to "Compute Engine" > "Health checks"
- Click "Create health check"
- Name: `http-health-check`
- Protocol: HTTP
- Port: 80
- Request path: `/`
- Check interval: 10 seconds
- Timeout: 5 seconds
- Healthy threshold: 2
- Unhealthy threshold: 3
- Click "Create"
- Return to your MIG and add this health check

### 4. Configure Initial Size

- Under your MIG configuration, set:
- Initial size: 2 (This ensures high availability)

Implementing Security Measures

IAM Role Configuration

#### 1. Create Custom IAM Roles

- Navigate to "IAM & Admin" > "Roles"
- Click "Create Role"
- Title: `VM-Operator`
- Description: "Role for operating VMs with limited permissions"
- ID: `vm_operator`
- Add the following permissions:
  - `compute.instances.get`
  - `compute.instances.list`
  - `compute.instances.start`
  - `compute.instances.stop`
  - `compute.instances.reset`
- Click "Create"

#### 2. Create a Service Account

- Navigate to "IAM & Admin" > "Service Accounts"
- Click "Create Service Account"
- Name: `vm-operations-sa`
- Description: "Service account for VM operations"
- Click "Create and Continue"
- Assign your custom role: `VM-Operator`
- Click "Done"

### 3. Assign Service Account to VMs

- Navigate to your VM instance template
  - Click "Edit"
  - Under "Service account", select your newly created service account
- Save the changes

### 4. Apply Principle of Least Privilege

- Review all IAM roles in your project
  - Remove unnecessary permissions
- Ensure each account has only the permissions required for its function
- Firewall Rule Setup

#### 1. Create Firewall Rules

- Navigate to "VPC Network" > "Firewall"
- Click "Create Firewall Rule"

#### 2. Configure Ingress Rules

Name: `allow-http-https`

Description: "Allow HTTP and HTTPS traffic"

- Network: default
  - Priority: 1000
  - Direction of traffic: Ingress
  - Action on match: Allow
  - Targets: Specified target tags
  - Target tags: `web-server`
  - Source filter: IP ranges
  - Source IP ranges: `0.0.0.0/0` (consider restricting to specific IP ranges for production)
- Protocols and ports:
- Select "Specified protocols and ports"
  - Check "TCP" and specify ports: 80,443
- Click "Create"

#### 3. Configure SSH Access Rule

Name: `allow-ssh-restricted`

Description: "Allow SSH from company IP range only"

- Network: default
- Priority: 900 (higher priority than default SSH rule)
- Direction of traffic: Ingress
- Action on match: Allow
- Targets: Specified target tags
- Target tags: `web-server`
- Source filter: IP ranges
- Source IP ranges: `YOUR_COMPANY_IP_RANGE` (e.g., `192.168.1.0/24`)
-

Protocols and ports:

Select "Specified protocols and ports"

Check "TCP" and specify port: 22

Click "Create"

#### 4. Deny All Other Traffic (Optional but Recommended)

- Name: deny-all-other
- Description: "Deny all other incoming traffic"
- Network: default
- Priority: 2000 (lower priority)
- Direction of traffic: Ingress
- Action on match: Deny
- Targets: All instances in the network
- Source filter: IP ranges
- Source IP ranges: 0.0.0.0/0
- Protocols and ports: All
- Click "Create"

#### 5. Apply Firewall Tags to VMs

- Navigate to your VM instance template
  - Click "Edit"
  - Under "Network tags", add web-server
- Save the changes

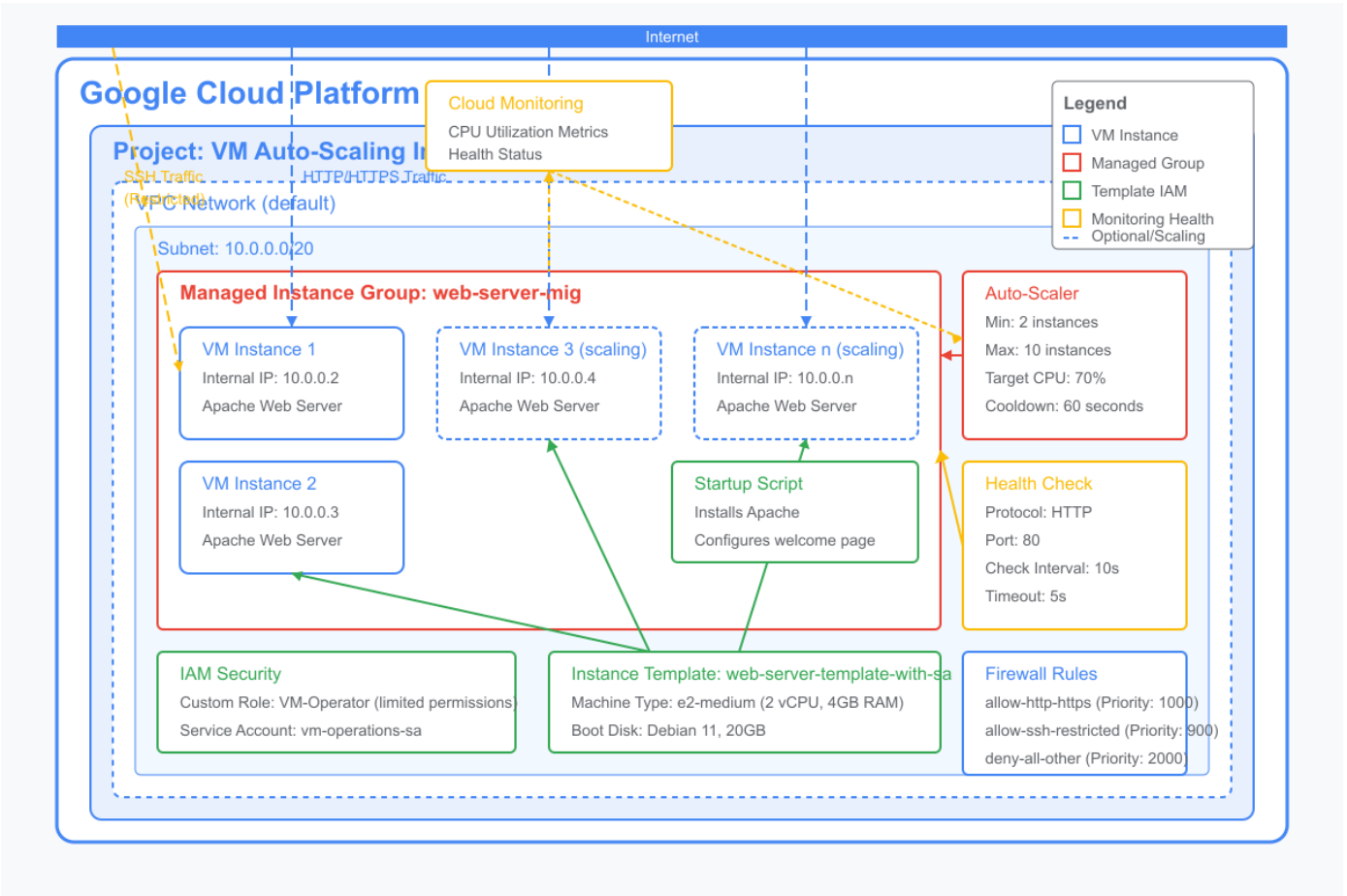
Architecture Design  
The architecture consists of:

- Instance Template with Debian 11 and Apache web server
- Managed Instance Group (MIG) with autoscaling based on CPU utilization
- HTTP/HTTPS Load Balancer (optional, for distributed traffic)
- Custom IAM roles and service accounts with least privilege

Firewall rules allowing only necessary traffic

Health checks for instance monitoring

The detailed architecture diagram is shown below:





# Testing and Verification

To test the implementation, follow these steps:

## 1. Verify VM Creation

- Check the Compute Engine dashboard to confirm VMs are running
- Verify they are part of the MIG and have the correct template applied

## 2. Test Auto-Scaling

- Generate CPU load to trigger auto-scaling:

```
# SSH into one of the
instances gcloud compute ssh
<instance-name> --
zone=<zone>

# Generate load
sudo apt-get
update sudo apt-
get install -y
stress stress --
cpu 2 --timeout
300
```

- Monitor the MIG dashboard to observe new instances being created

## 3. Verify Security Configuration

- Check that IAM roles are correctly applied

```
gcloud iam service-accounts get-iam-policy vm-operations-
sa@<project-id>.iam.gserviceaccount.com
```

- Test firewall rules by attempting to access:
  - HTTP/HTTPS: Should succeed from any IP
  - SSH: Should only succeed from company IP range

Other ports: Should be blocked

## 4. Load Testing

- Use tools like Apache Benchmark or JMeter to generate HTTP load
- Observe auto-scaling behavior under different load patterns

### Conclusion

This implementation provides a scalable, secure virtual machine environment in Google Cloud Platform. The auto-scaling policies ensure resource efficiency by automatically

adjusting the number of instances based on workload, while the security measures protect the environment from unauthorized access.

The key benefits of this implementation include:

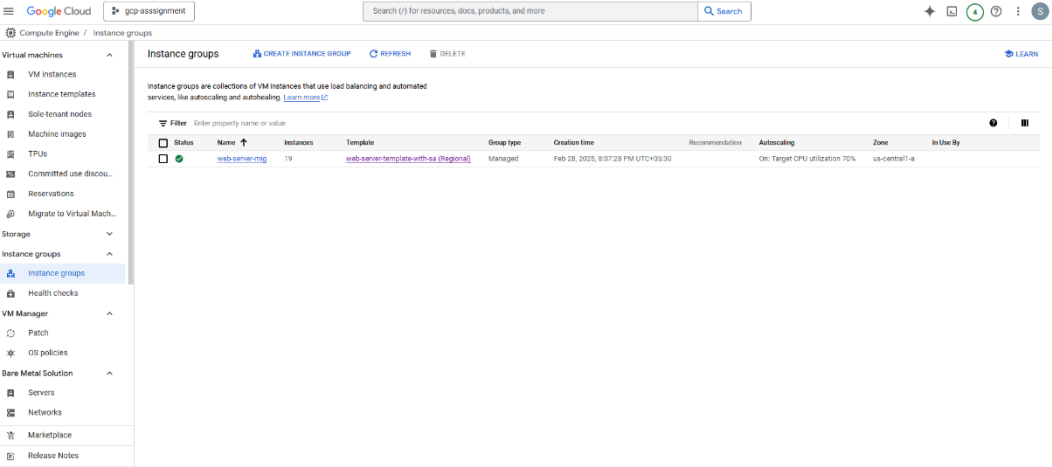
1. **Scalability:** Automatic scaling from 2 to 10 instances based on CPU utilization.
2. **Cost Efficiency:** Resources are allocated only when needed and scaled down when demand decreases.

3. **High Availability:** Multiple instances across different zones ensure service continuity.
4. **Security:** Robust security measures including custom IAM roles and firewall rules.
5. **Monitoring:** Health checks to ensure all instances are functioning properly.

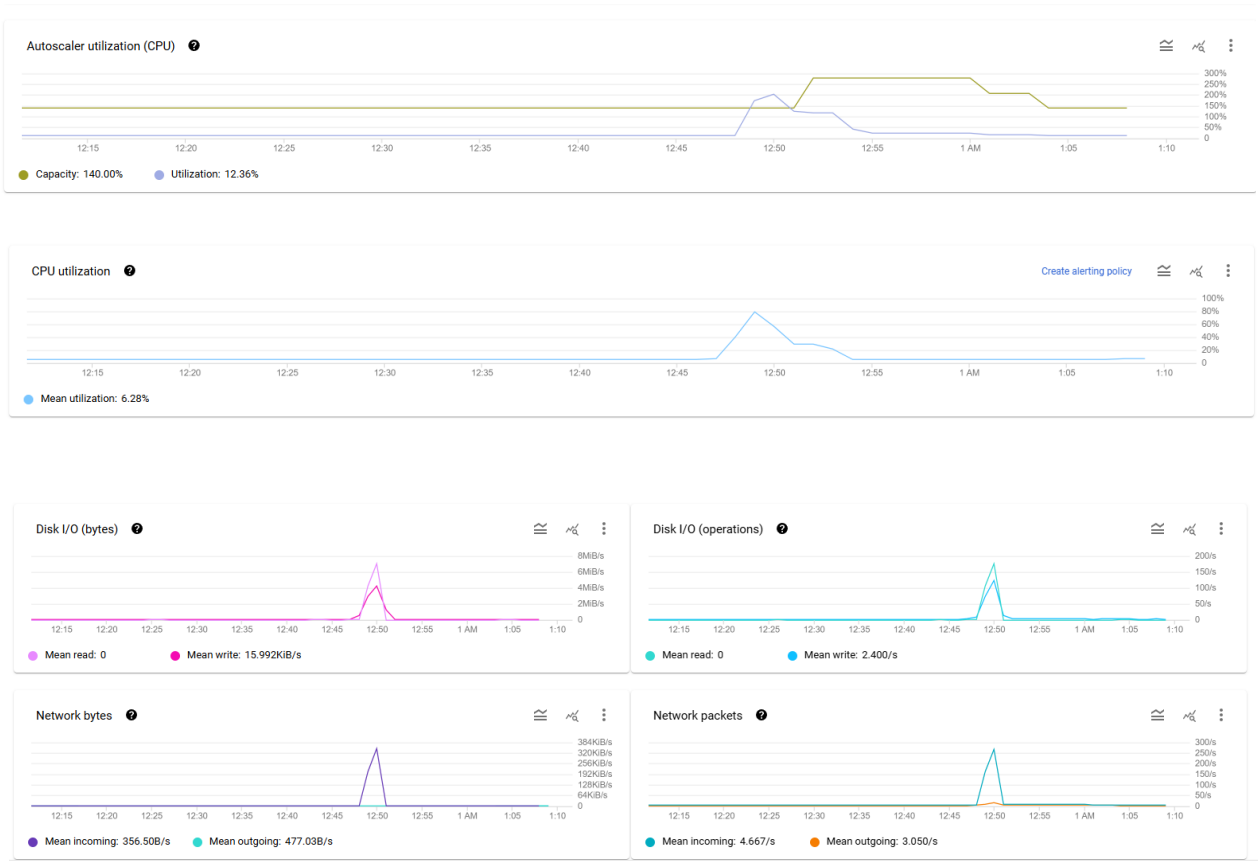
For production environments, consider:

- ▮ Implementing additional security measures like VPC Service Controls
  - ▮ Setting up monitoring and alerting using Cloud Monitoring
  - ▮ Implementing disaster recovery procedures
  - ▮ Regularly reviewing and updating security policies
-

# SOME SCREENSHOTS



MANAGED  
INSTANCE  
GROUP



|                            |                |  |                              |         |       |   |   |   |   |
|----------------------------|----------------|--|------------------------------|---------|-------|---|---|---|---|
| Google Cloud               | gcp-assignment | Search (y) for resources, docs, products, and more | Search                       | +       | 🔍     | 🔍 | 🔍 | 🔍 | 🔍 |
| Compute Engine             | VM instances   | CREATE INSTANCE                                    | IMPORT VM                    | REFRESH | LEARN |   |   |   |   |
| Virtual machines           | VM instances   | Filter   | Enter property name or value |         |       |   |   |   |   |
| Instance templates         |                |  |                              |         |       |   |   |   |   |
| Sole-tenant nodes          |                |  |                              |         |       |   |   |   |   |
| Machine Images             |                |  |                              |         |       |   |   |   |   |
| TPUs                       |                |  |                              |         |       |   |   |   |   |
| Committed use discount     |                |  |                              |         |       |   |   |   |   |
| Reservations               |                |  |                              |         |       |   |   |   |   |
| Migrate to Virtual Machine |                |  |                              |         |       |   |   |   |   |
| Storage                    |                |  |                              |         |       |   |   |   |   |
| Instance groups            |                |  |                              |         |       |   |   |   |   |
| Health checks              |                |  |                              |         |       |   |   |   |   |
| VM Manager                 |                |  |                              |         |       |   |   |   |   |
| Patch                      |                |  |                              |         |       |   |   |   |   |
| OS policies                |                |  |                              |         |       |   |   |   |   |
| Bare Metal Solution        |                |  |                              |         |       |   |   |   |   |
| Servers                    |                |  |                              |         |       |   |   |   |   |
| Networks                   |                |  |                              |         |       |   |   |   |   |
| Marketplace                |                |  |                              |         |       |   |   |   |   |
| Release Notes              |                |  |                              |         |       |   |   |   |   |

## VM INSTANCES

|                            |                             |  |                |                       |        |   |   |   |   |
|----------------------------|-----------------------------|--|----------------|-----------------------|--------|---|---|---|---|
| Google Cloud               | gcp-assignment              | Search (y) for resources, docs, products, and more | Search         | +                     | 🔍      | 🔍 | 🔍 | 🔍 | 🔍 |
| Compute Engine             | web-server-template-with-sa | CREATE VM  | CREATE SIMILAR | CREATE INSTANCE GROUP | DELETE |   |   |   |   |
| Virtual machines           | VM instances                |  |                |                       |        |   |   |   |   |
| Instance templates         |                             |  |                |                       |        |   |   |   |   |
| Sole-tenant nodes          |                             |  |                |                       |        |   |   |   |   |
| Machine Images             |                             |  |                |                       |        |   |   |   |   |
| TPUs                       |                             |  |                |                       |        |   |   |   |   |
| Committed use discount     |                             |  |                |                       |        |   |   |   |   |
| Reservations               |                             |  |                |                       |        |   |   |   |   |
| Migrate to Virtual Machine |                             |  |                |                       |        |   |   |   |   |
| Storage                    |                             |  |                |                       |        |   |   |   |   |
| Instance groups            |                             |  |                |                       |        |   |   |   |   |
| Health checks              |                             |  |                |                       |        |   |   |   |   |
| VM Manager                 |                             |  |                |                       |        |   |   |   |   |
| Patch                      |                             |  |                |                       |        |   |   |   |   |
| OS policies                |                             |  |                |                       |        |   |   |   |   |
| Bare Metal Solution        |                             |  |                |                       |        |   |   |   |   |
| Servers                    |                             |  |                |                       |        |   |   |   |   |
| Networks                   |                             |  |                |                       |        |   |   |   |   |
| Marketplace                |                             |  |                |                       |        |   |   |   |   |
| Release Notes              |                             |  |                |                       |        |   |   |   |   |

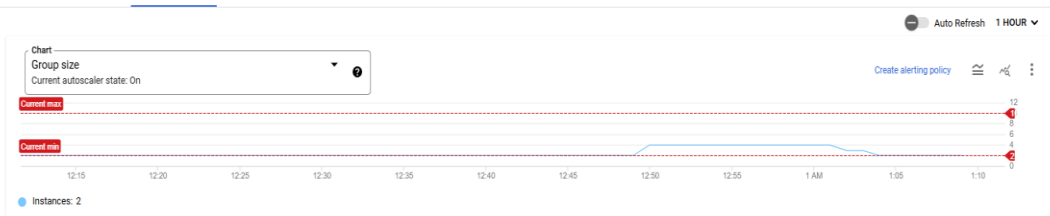
## INSTANCE TEMPLATE

|                           |                |   |        |   |   |   |   |   |   |
|---------------------------|----------------|---|--------|---|---|---|---|---|---|
| Google Cloud              | gcp-assignment | roles   | Search | + | 🔍 | 🔍 | 🔍 | 🔍 | 🔍 |
| IAM & Admin               | Roles          | Role: projects/gcp-assignment-roles-vm_operator |        |   |   |   |   |   |   |
| IAM                       |                |   |        |   |   |   |   |   |   |
| PKM                       |                |   |        |   |   |   |   |   |   |
| Principal Access Bound... |                |   |        |   |   |   |   |   |   |
| Organizations             |                |   |        |   |   |   |   |   |   |
| Identity & Organization   |                |   |        |   |   |   |   |   |   |
| Policy Troubleshooter     |                |   |        |   |   |   |   |   |   |
| Policy Analyzer           |                |   |        |   |   |   |   |   |   |
| Organization Policies     |                |   |        |   |   |   |   |   |   |
| Service Accounts          |                |   |        |   |   |   |   |   |   |
| Workload Identity Fede... |                |   |        |   |   |   |   |   |   |
| Workforce Identity Fed... |                |   |        |   |   |   |   |   |   |
| Labels                    |                |   |        |   |   |   |   |   |   |
| Tags                      |                |   |        |   |   |   |   |   |   |
| Settings                  |                |   |        |   |   |   |   |   |   |
| Privacy & Security        |                |   |        |   |   |   |   |   |   |
| Identity-Aware Proxy      |                |   |        |   |   |   |   |   |   |
| Roles                     |                |   |        |   |   |   |   |   |   |
| Audit logs                |                |   |        |   |   |   |   |   |   |

## IAM ROLES

|                           |                   |                        |                      |       |   |   |   |   |   |
|---------------------------|-------------------|------------------------|----------------------|-------|---|---|---|---|---|
| Google Cloud              | gcp-assignment    | firewall rules         | Search               | +     | 🔍 | 🔍 | 🔍 | 🔍 | 🔍 |
| Network Security          | Firewall policies | CREATE FIREWALL POLICY | CREATE FIREWALL RULE | LEARN |   |   |   |   |   |
| Secure Web Proxy          |                   |                        |                      |       |   |   |   |   |   |
| Cloud Armor               |                   |                        |                      |       |   |   |   |   |   |
| DocS Dashboard            |                   |                        |                      |       |   |   |   |   |   |
| Cloud Armor policies      |                   |                        |                      |       |   |   |   |   |   |
| Adaptive Protection       |                   |                        |                      |       |   |   |   |   |   |
| Cloud Armor Service Tier  |                   |                        |                      |       |   |   |   |   |   |
| Cloud IDS                 |                   |                        |                      |       |   |   |   |   |   |
| IDS Dashboard             |                   |                        |                      |       |   |   |   |   |   |
| IDS endpoints             |                   |                        |                      |       |   |   |   |   |   |
| IDS Threats               |                   |                        |                      |       |   |   |   |   |   |
| Cloud NGFW                |                   |                        |                      |       |   |   |   |   |   |
| Dashboard                 |                   |                        |                      |       |   |   |   |   |   |
| Firewall policies         |                   |                        |                      |       |   |   |   |   |   |
| Threats                   |                   |                        |                      |       |   |   |   |   |   |
| Firewall endpoints        |                   |                        |                      |       |   |   |   |   |   |
| Common components         |                   |                        |                      |       |   |   |   |   |   |
| Address groups            |                   |                        |                      |       |   |   |   |   |   |
| Security profiles         |                   |                        |                      |       |   |   |   |   |   |
| TLS inspection policies   |                   |                        |                      |       |   |   |   |   |   |
| SSL policies              |                   |                        |                      |       |   |   |   |   |   |
| Authentication Configu... |                   |                        |                      |       |   |   |   |   |   |

## FIREWALL RULES



## Repository Information

The complete source code for this implementation is available in the GitHub repository:

[https://github.com/suvosom1997/VCC\\_GCP\\_assignment](https://github.com/suvosom1997/VCC_GCP_assignment)

[\(https://github.com/suvosom1997/VCC\\_GCP\\_assignment\)](https://github.com/suvosom1997/VCC_GCP_assignment)

# Video Demonstration

A video demonstration of this implementation is available at:

**<https://youtu.be/gQxDO1bvn9U>**  
**(<https://youtu.be/gQxDO1bvn9U>)**

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## Plagiarism Statement

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