Project 1: Multi-Tier Web Application with Auto-Scaling

Project Report
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1. Introduction

This project demonstrates the implementation of a **highly available, fault-tolerant, and scalable web application architecture** on AWS using:

- **EC2 Auto Scaling Group (ASG)**
- **Application Load Balancer (ALB)**
- **Target Groups**
- **CloudWatch Monitoring**
- **Scaling Policies**
- **Apache JMeter Load Testing**

The primary objective was to validate the **scale-out** and **scale-in** behaviour of the Auto Scaling Group under simulated heavy traffic.

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2. Architecture Overview

A scalable architecture was deployed where the ALB routes traffic across EC2 instances managed by the ASG. CloudWatch monitors performance metrics and triggers automatic scaling events.

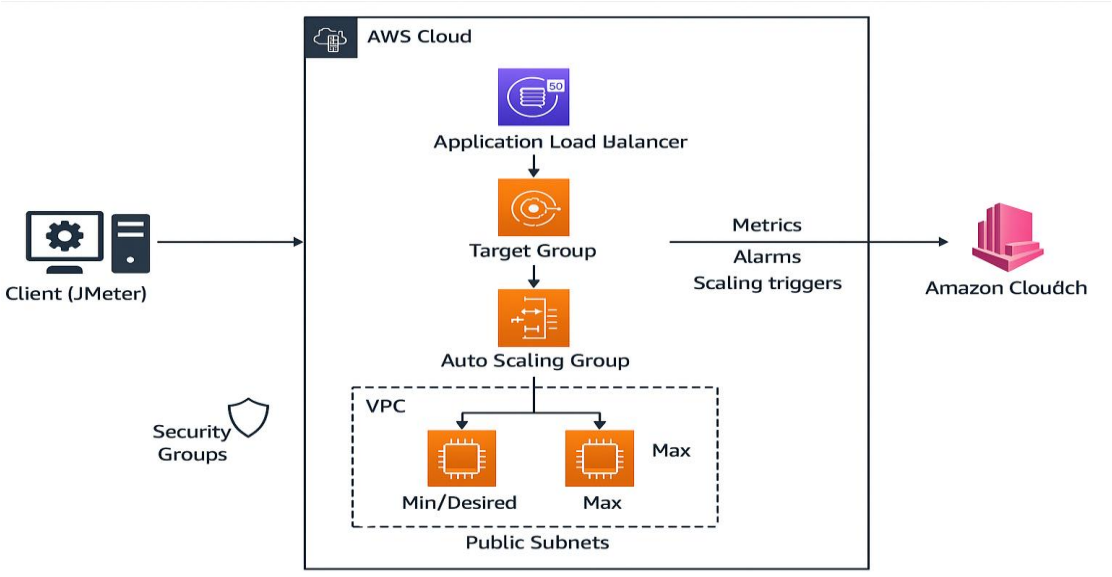
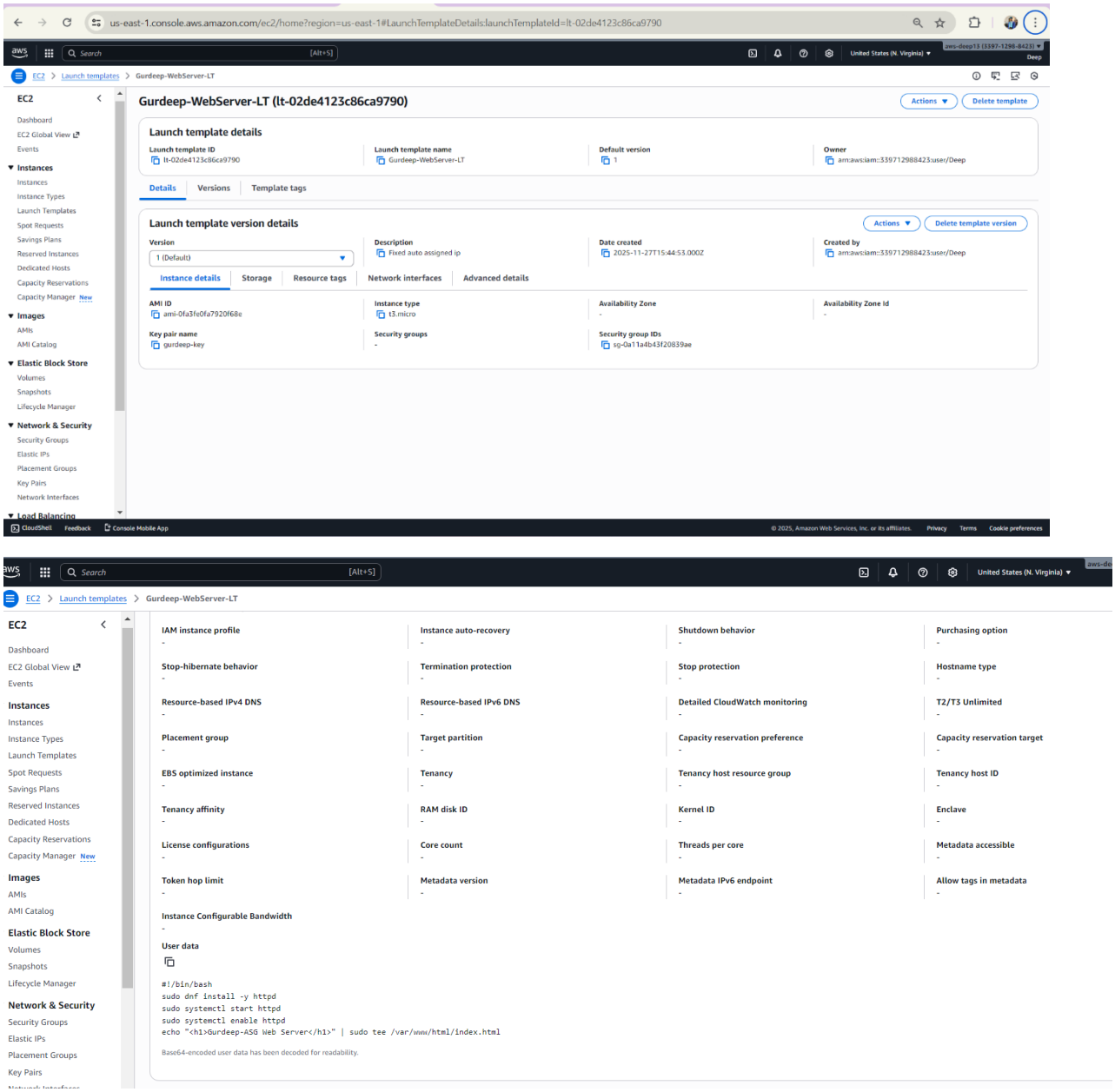


Fig: Architecture Diagram

3. AWS Components Used

3.1 EC2 Launch Template

- Configured with Amazon Linux 2 AMI
- Bootstrapped using user data to install Apache web server
- Created a custom HTML page: *“Gurdeep-ASG Web Server”*

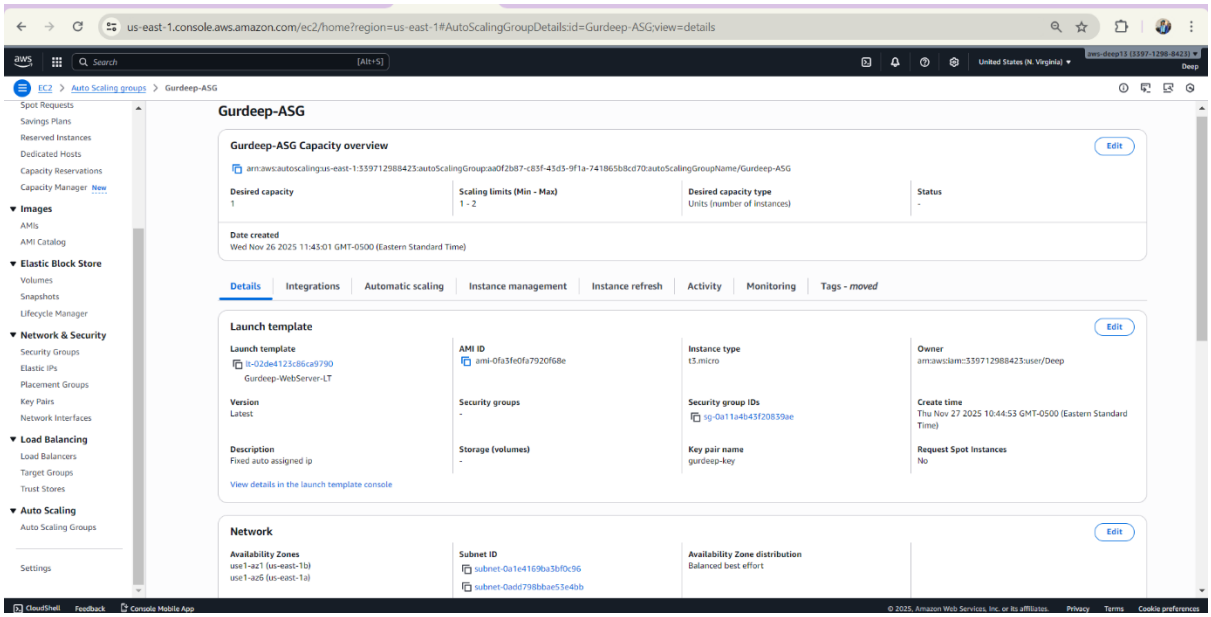


Launch Template settings

3.2 Auto Scaling Group (ASG)

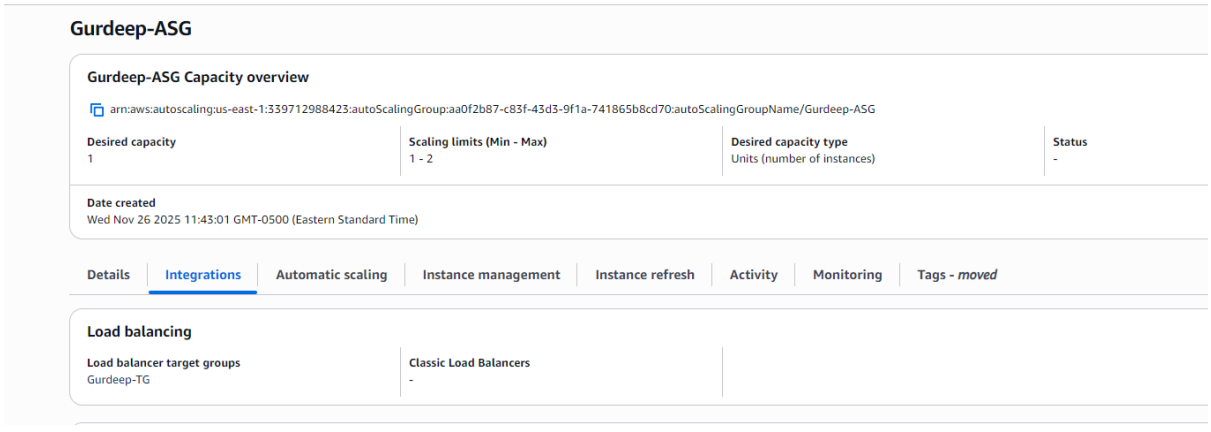
- Minimum capacity: **1**

- Desired capacity: **1**
- Maximum capacity: **3**
- Subnets: **us-east-1a**, **us-east-1b**



3.3 Application Load Balancer (ALB)

- Internet-facing
- Listener: **HTTP 80**
- Default action: Forward to Target Group

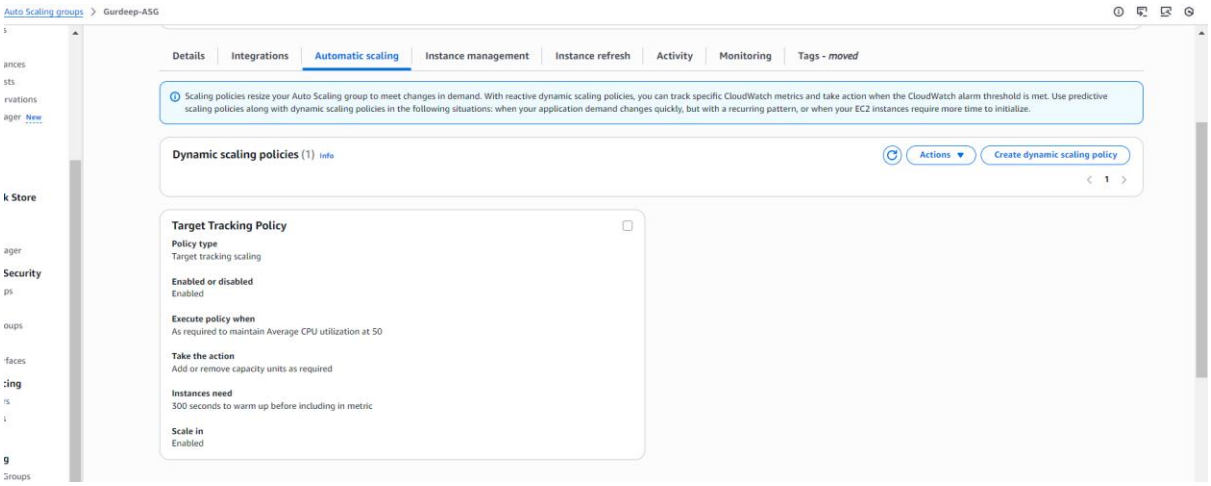


3.4 Target Group

- Protocol: HTTP
- Port: 80
- Health checks: /

3.5 Scaling Policies

- **Scale Out:** CPU > 50%
- **Scale In:** CPU < 20%
- Instance warmup: 300 seconds



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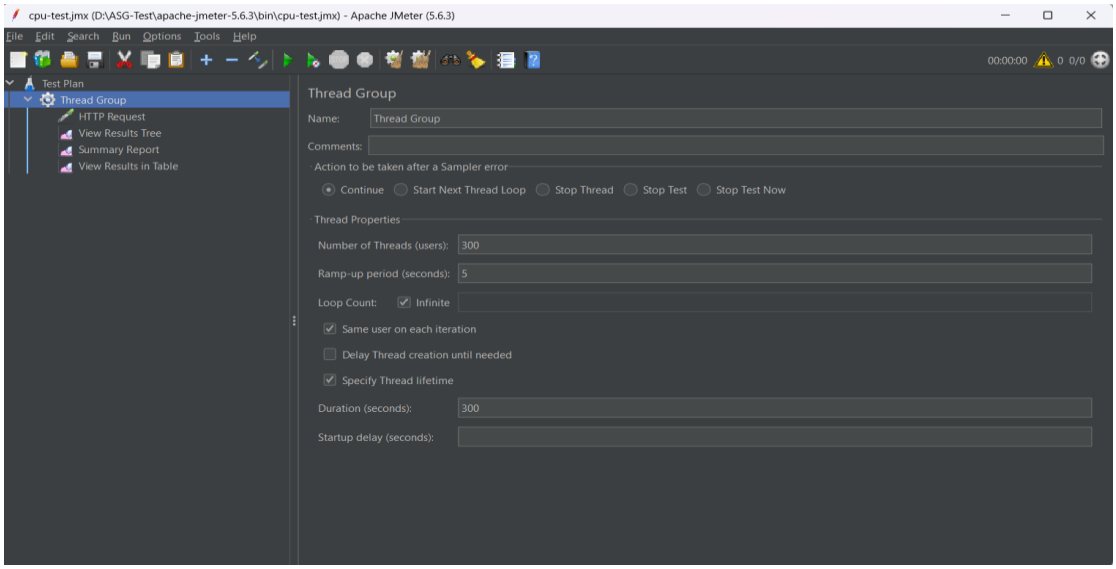
4. Load Testing with Apache JMeter

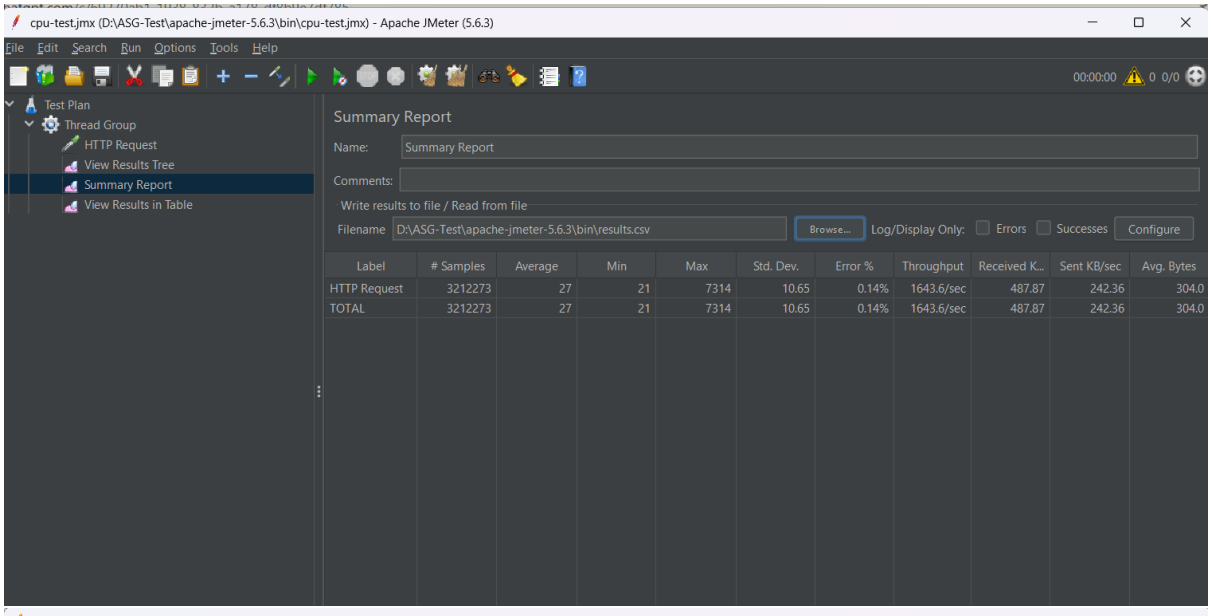
Apache JMeter was used to simulate real-world high traffic to validate scaling behaviour.

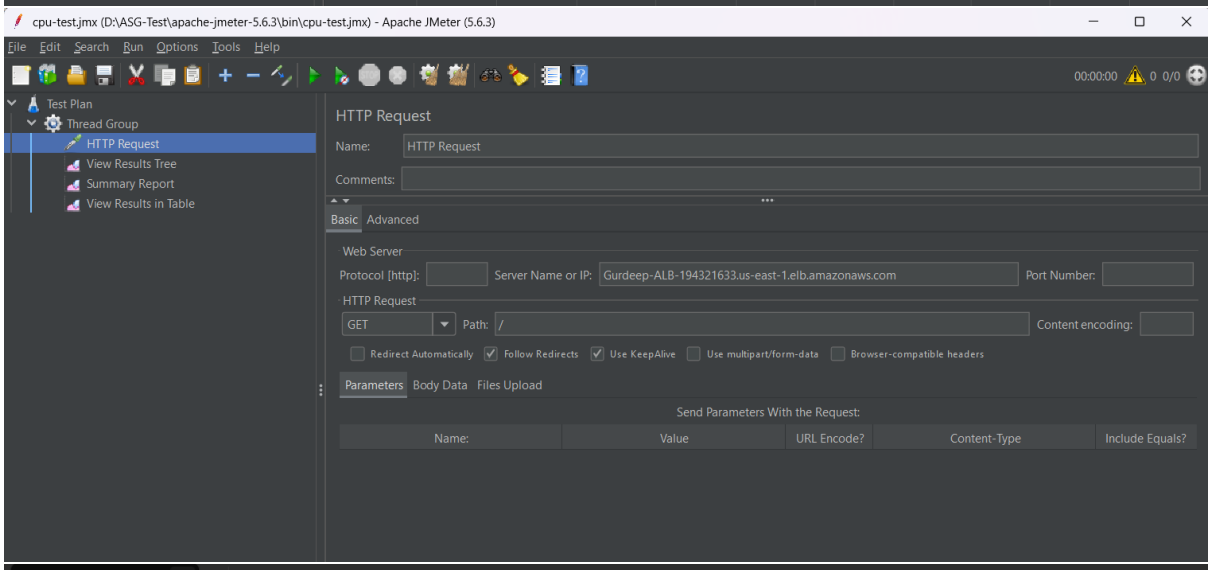
4.1 Test Plan Configuration

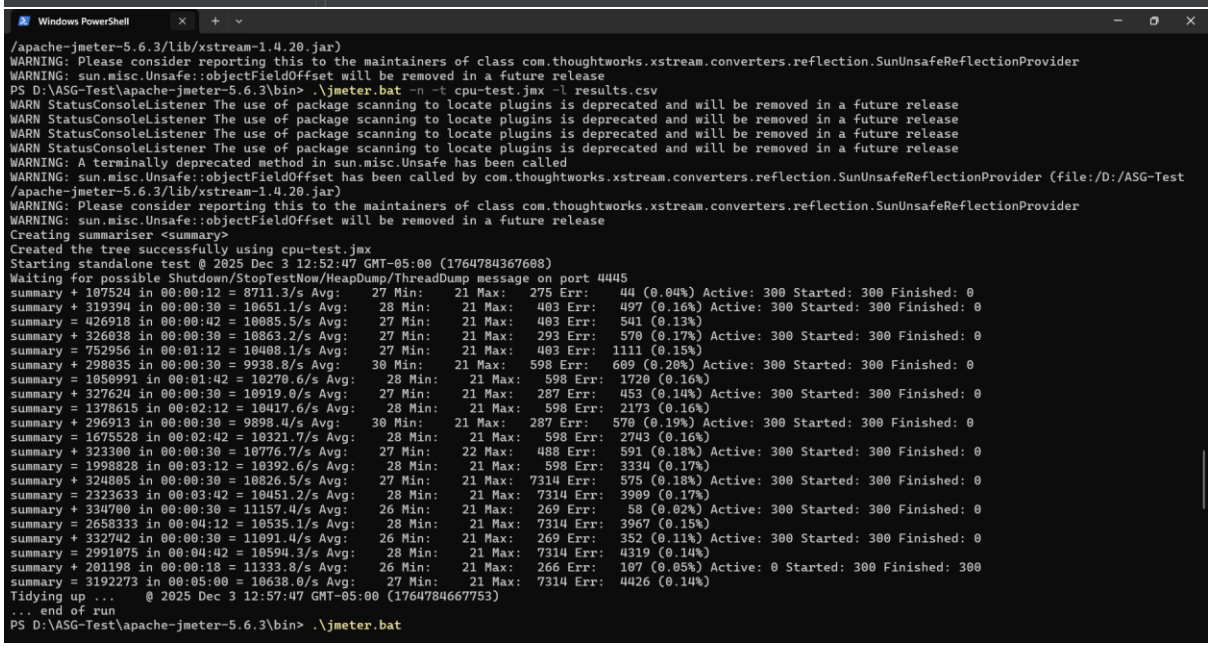
- Threads (users): **300**
- Ramp-up: **5 seconds**
- Test Duration: **300 seconds**
- Target: ALB DNS endpoint
- Test executed using **CLI mode**:

```
jmeter.bat -n -t test-plan.jmx -l results.csv
```




cpu-test.jmx (D:\ASG-Test\apache-jmeter-5.6.3\bin\cpu-test.jmx) - Apache JMeter (5.6.3)
File Edit Search Run Options Tools Help
00:00:00 0 0/0
Test Plan
Thread Group
HTTP Request
View Results Tree
Summary Report
View Results in Table
Summary Report
Name: Summary Report
Comments:
Write results to file / Read from file
Filename D:\ASG-Test\apache-jmeter-5.6.3\bin\results.csv
Browse... Log/Display Only: Errors Successes Configure
Label # Samples Average Min Max Std. Dev. Error % Throughput Received K... Sent KB/sec Avg. Bytes
HTTP Request 3212273 27 21 7314 10.65 0.14% 1643.6/sec 487.87 242.36 304.0
TOTAL 3212273 27 21 7314 10.65 0.14% 1643.6/sec 487.87 242.36 304.0

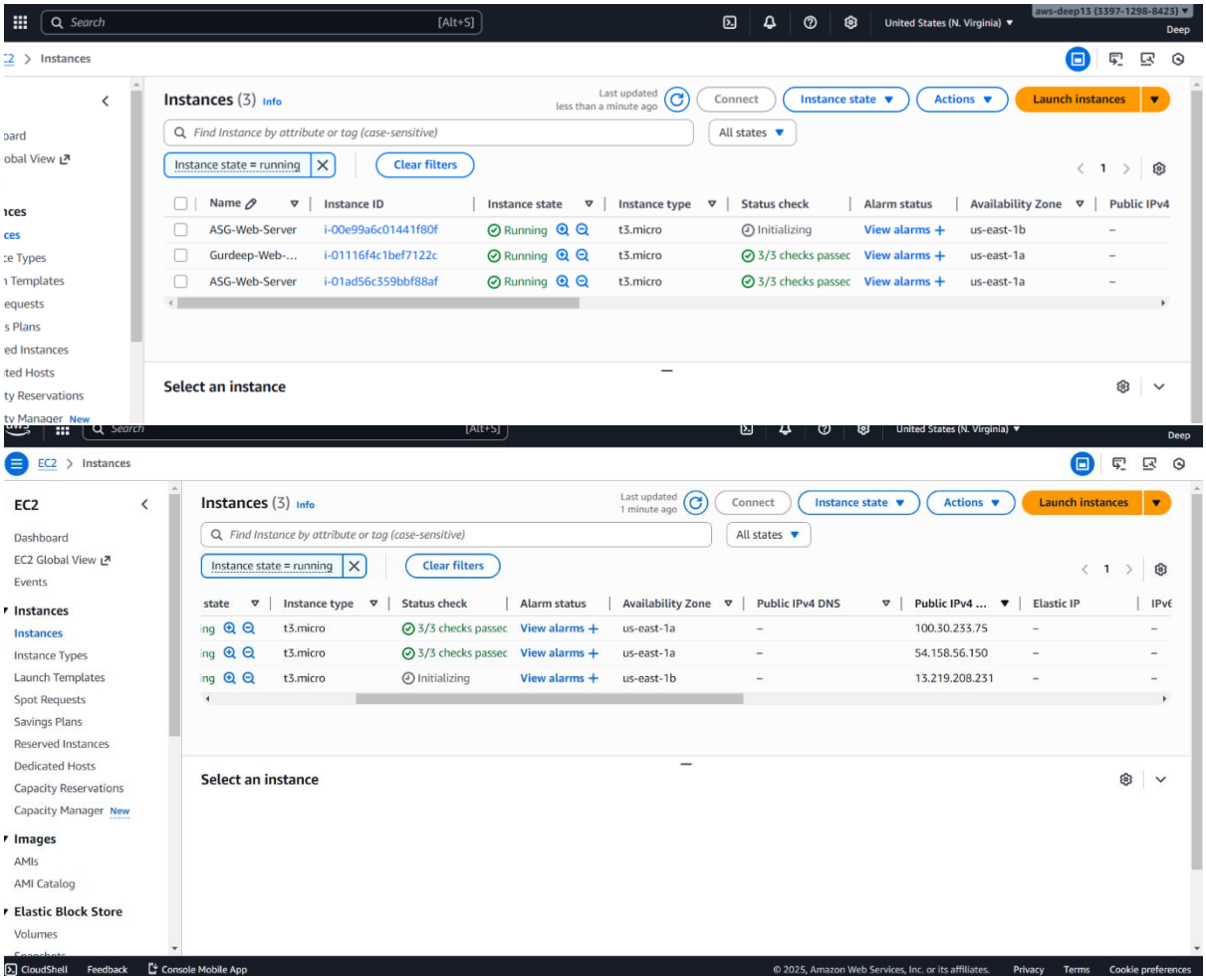

cpu-test.jmx (D:\ASG-Test\apache-jmeter-5.6.3\bin\cpu-test.jmx) - Apache JMeter (5.6.3)
File Edit Search Run Options Tools Help
00:00:00 0 0/0
Test Plan
Thread Group
HTTP Request
View Results Tree
Summary Report
View Results in Table
HTTP Request
Name: HTTP Request
Comments:
Basic Advanced
Web Server
Protocol [http]: Server Name or IP: Gurdeep-ALB-194321633.us-east-1.elb.amazonaws.com Port Number:
HTTP Request
GET Path: / Content encoding:
Redirect Automatically Follow Redirects Use KeepAlive Use multipart/form-data Browser-compatible headers
Parameters Body Data Files Upload
Send Parameters With the Request:
Name: Value URL Encode? Content-Type Include Equals?


Windows PowerShell
/apache-jmeter-5.6.3/lib/xstream-1.4.20.jar)
WARNING: Please consider reporting this to the maintainers of class com.thoughtworks.xstream.converters.reflection.SunUnsafeReflectionProvider
WARNING: sun.misc.Unsafe::objectFieldOffset will be removed in a future release
PS D:\ASG-Test\apache-jmeter-5.6.3\bin> .\jmeter.bat -n -t cpu-test.jmx -l results.csv
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future release
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future release
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future release
WARN StatusConsoleListener The use of package scanning to locate plugins is deprecated and will be removed in a future release
WARNING: A terminally deprecated method in sun.misc.Unsafe has been called
WARNING: sun.misc.Unsafe::objectFieldOffset has been called by com.thoughtworks.xstream.converters.reflection.SunUnsafeReflectionProvider (file:/D:/ASG-Test
/apache-jmeter-5.6.3/lib/xstream-1.4.20.jar)
WARNING: Please consider reporting this to the maintainers of class com.thoughtworks.xstream.converters.reflection.SunUnsafeReflectionProvider
WARNING: sun.misc.Unsafe::objectFieldOffset will be removed in a future release
Creating summariser <summary>
Created the tree successfully using cpu-test.jmx
Starting standalone test @ 2025 Dec 3 12:52:47 GMT-05:00 (1764784367608)
Waiting for possible Shutdown/StopTestNow/HeapDump/ThreadDump message on port 4445
summary + 107524 in 00:00:12 = 8711.3/s Avg: 27 Min: 21 Max: 275 Err: 44 (0.04%) Active: 300 Started: 300 Finished: 0
summary + 319394 in 00:00:30 = 10651.1/s Avg: 28 Min: 21 Max: 403 Err: 497 (0.16%) Active: 300 Started: 300 Finished: 0
summary = 426918 in 00:00:42 = 10085.5/s Avg: 27 Min: 21 Max: 403 Err: 541 (0.13%)
summary + 326038 in 00:00:30 = 10863.2/s Avg: 27 Min: 21 Max: 293 Err: 570 (0.17%) Active: 300 Started: 300 Finished: 0
summary = 752956 in 00:01:12 = 10408.1/s Avg: 27 Min: 21 Max: 403 Err: 1111 (0.15%)
summary + 298035 in 00:00:30 = 9938.8/s Avg: 30 Min: 21 Max: 598 Err: 609 (0.20%) Active: 300 Started: 300 Finished: 0
summary = 1050991 in 00:01:42 = 10270.6/s Avg: 28 Min: 21 Max: 598 Err: 1720 (0.16%)
summary + 327624 in 00:00:30 = 10919.0/s Avg: 27 Min: 21 Max: 287 Err: 453 (0.14%) Active: 300 Started: 300 Finished: 0
summary = 1378615 in 00:02:12 = 10417.6/s Avg: 28 Min: 21 Max: 598 Err: 2173 (0.16%)
summary + 296913 in 00:00:30 = 9898.4/s Avg: 30 Min: 21 Max: 287 Err: 570 (0.19%) Active: 300 Started: 300 Finished: 0
summary = 1675528 in 00:02:42 = 10321.7/s Avg: 28 Min: 21 Max: 598 Err: 2743 (0.16%)
summary + 323300 in 00:00:30 = 10776.7/s Avg: 27 Min: 22 Max: 488 Err: 591 (0.18%) Active: 300 Started: 300 Finished: 0
summary = 1998828 in 00:03:12 = 10392.6/s Avg: 28 Min: 21 Max: 598 Err: 3334 (0.17%)
summary + 324805 in 00:00:30 = 10826.5/s Avg: 27 Min: 21 Max: 7314 Err: 575 (0.18%) Active: 300 Started: 300 Finished: 0
summary = 2323633 in 00:03:42 = 10451.2/s Avg: 28 Min: 21 Max: 7314 Err: 3909 (0.17%)
summary + 334700 in 00:00:30 = 11157.4/s Avg: 26 Min: 21 Max: 269 Err: 58 (0.02%) Active: 300 Started: 300 Finished: 0
summary = 2658333 in 00:04:12 = 10535.1/s Avg: 28 Min: 21 Max: 7314 Err: 3967 (0.15%)
summary + 332742 in 00:00:30 = 11091.4/s Avg: 26 Min: 21 Max: 269 Err: 352 (0.11%) Active: 300 Started: 300 Finished: 0
summary = 2991075 in 00:04:42 = 10594.3/s Avg: 28 Min: 21 Max: 7314 Err: 4319 (0.14%)
summary + 201198 in 00:00:18 = 11333.8/s Avg: 26 Min: 21 Max: 266 Err: 107 (0.05%) Active: 0 Started: 300 Finished: 300
summary = 3192273 in 00:05:00 = 10638.0/s Avg: 27 Min: 21 Max: 7314 Err: 4426 (0.14%)
Tidying up ... @ 2025 Dec 3 12:57:47 GMT-05:00 (1764784667753)
... end of run
PS D:\ASG-Test\apache-jmeter-5.6.3\bin> .\jmeter.bat

5. Results & Observations

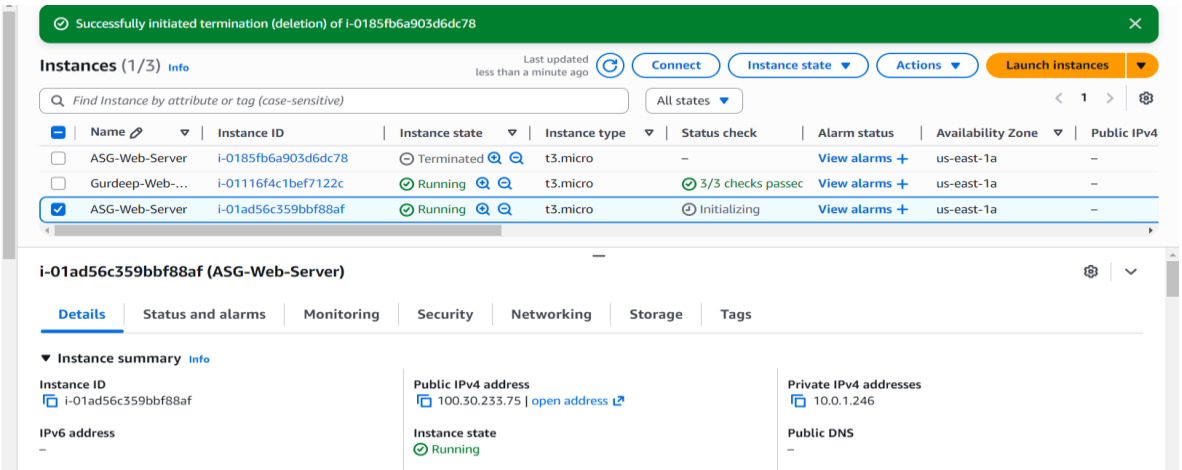
5.1 Scale-Out Behavior

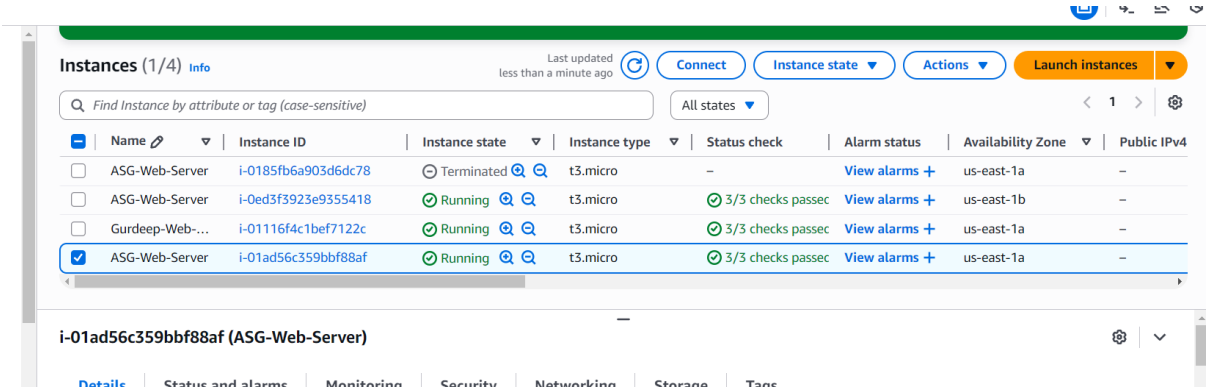
During the load test, the ASG successfully launched new instances as CPU utilization surpassed the scaling threshold.



5.2 Scale-In Behavior

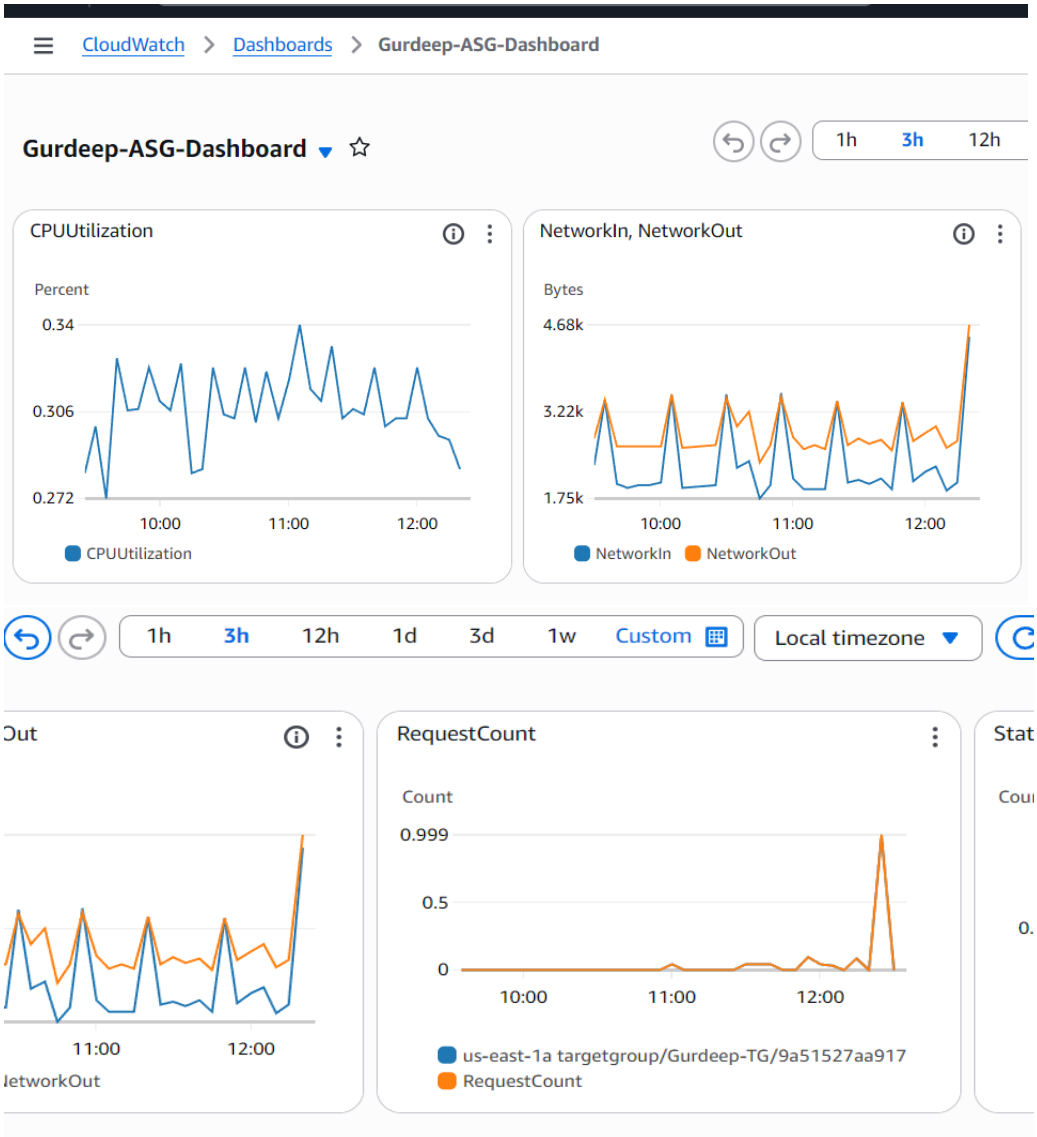
After test completion, CPU utilization dropped and the ASG terminated extra instances, returning to the desired count.

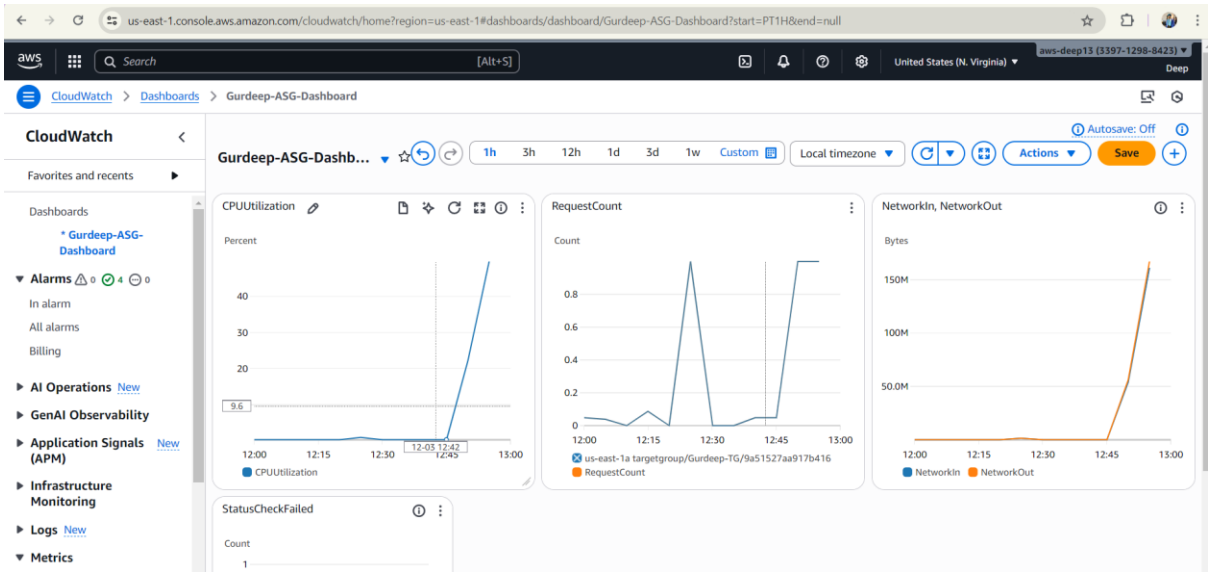




5.3 CloudWatch Metrics Observed

- **CPU Utilization** spiked during load test
- **RequestCount** increased significantly
- **NetworkIn/NetworkOut** displayed heavy throughput
- **Auto Scaling Events** were logged





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6. Conclusion

This project successfully demonstrates:

- Deployment of a **production-ready scalable architecture** using EC2 Auto Scaling
- Efficient traffic distribution through an **Application Load Balancer**
- Elastic and automated scaling through **CloudWatch alarms**
- Load testing validation using **Apache JMeter**
- Proper scale-out and scale-in behaviour during demand fluctuation

The system is **highly available**, **fault tolerant**, and **cost optimized**.

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7. Deliverables

Included in project ZIP file:

File	Description
Documentation.pdf	Final project report
Architecture-Diagram.png	System architecture
results.csv	JMeter load testing results
test-plan.jmx	JMeter test plan
screenshots/	All project screenshots

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8. Cleanup Steps (to avoid AWS charges)

1. Delete **ALB** (costs money continuously)
2. Delete **Target Group**
3. Delete **Auto Scaling Group**
4. Delete **Launch Template**
5. Terminate **EC2 instances**
6. Delete **Security Groups** (if unused)
7. Remove **CloudWatch Dashboards**
8. Delete **CloudWatch Alarms**