

CLOUD COMPUTING

University of Massachusetts Lowell



AZURE PROJECT

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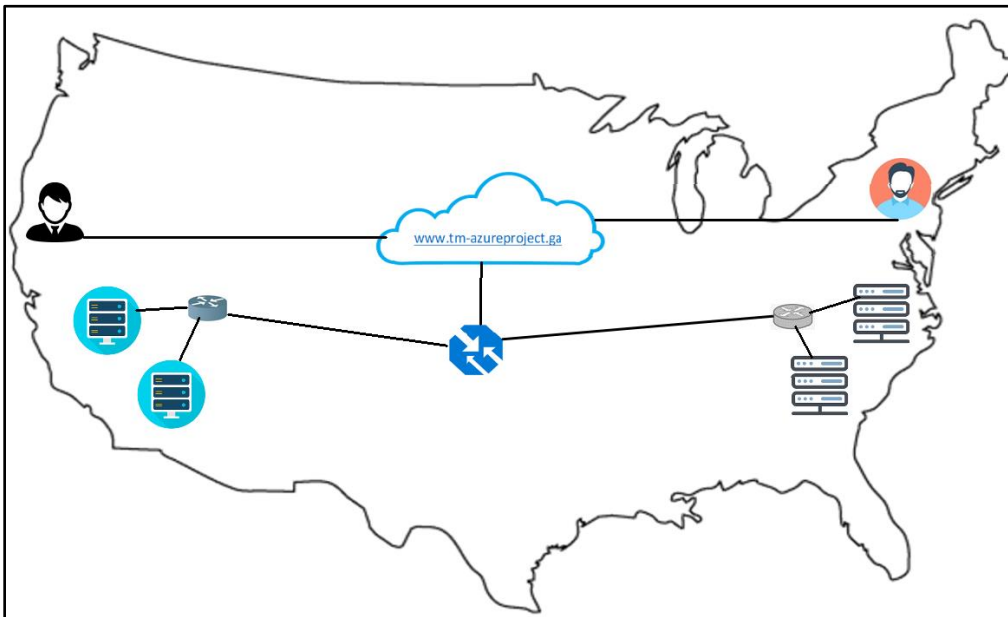
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Introduction:

When I started this project, I do not have any hands-on experience with any cloud services or platforms. However, I did work on the course lab exercises every week and it did really help me to finish this project in time. I am happy that I started my cloud learnings with Azure. The account setup hardly takes couple of minutes. Since I wanted to explore more, I did play with many tools and services offered on Azure and it's a fun and great learning experience on the whole.

For my Azure project, I'm going to deploy a website (www.tm-azureproject.ga) with two sets of servers in two different regions. The first set of servers will be in the US WEST and another set of servers in the US EAST/Central. Since there are multiple servers, I do plan to deploy a load balancer on top of them. So, the main purpose of the load balancer here is to direct the traffic to the closest domain and divide the load between the available servers in my fleet for that particular region. Since Azure has an auto-scaling feature and if I get to have 10 servers for my application, my user needs not to be worried about which of these 10 servers he have to reach because the load balancer will route the traffic to whichever server is free. This will be my basic architecture.



To implement and deploy the intended architecture I'll be using the below services –

1. Virtual Machines
2. Virtual Networks
3. Application Gateways
4. Traffic Manager
5. DNS
6. Application Insights
7. Public IP addresses
8. Recovery System Service
9. Alerts

VMs Deployment:

Azure offers a wide range of VM sizes and the VMs will be deployed in less than a minute in the region of the choosing. I was mindful in choosing the size concerning the cost because I do not want to exhaust my free credits. I have successfully created my 4 VMs as in 2sets in two regions.

[Home](#) >

Virtual machines

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[+ Add](#) [Reservations](#) [Edit columns](#) [Refresh](#) [Try preview](#) [Assign tags](#) [Start](#) [Restart](#) [Stop](#) [Delete](#) [Services](#)

Try the new virtual machine resource browser! This experience is faster and has improved sorting and filtering capabilities. Please note that the new experience will not show classic virtual machines and does not include support for some columns such as maintenance status.

Subscriptions: Azure subscription 1

4 items

<input type="checkbox"/>	Name ↑↓	Type ↑↓	Status	Resource group ↑↓	Location ↑↓	Source	Maintenance status	Subscription ↑↓
<input type="checkbox"/>	server1-east	Virtual machine	Running	azprojUSE	East US	Marketplace	-	Azure subscription
<input type="checkbox"/>	server1-west	Virtual machine	Running	azprojUSW	West US	Marketplace	-	Azure subscription
<input type="checkbox"/>	server2-east	Virtual machine	Running	azprojUSE	East US	Marketplace	-	Azure subscription
<input type="checkbox"/>	server2-west	Virtual machine	Running	azprojUSW	West US	Marketplace	-	Azure subscription

VM Configuration:

After the VMs went up and running, I need to configure these servers. To do that I used the PowerShell, which is available on the Azure portal. Firstly, the servers are updated with the “sudo apt-get update” command, and after that apache2 software has been installed on the servers with the “sudo apt-get install apache2” command.

```
tharun@server1-east:~$ sudo apt-get update
Hit:1 http://azure.archive.ubuntu.com/ubuntu bionic InRelease
Get:2 http://azure.archive.ubuntu.com/ubuntu bionic-updates InRelease [88.7 kB]
Get:3 http://azure.archive.ubuntu.com/ubuntu bionic-backports InRelease [74.6 kB]
Get:4 http://security.ubuntu.com/ubuntu bionic-security InRelease [88.7 kB]
Get:5 http://azure.archive.ubuntu.com/ubuntu bionic/universe amd64 Packages [8570 kB]

Processing triggers for systemd (237-3ubuntu10.42) ...
Processing triggers for man-db (2.8.3-2ubuntu0.1) ...
Processing triggers for ufw (0.36-0ubuntu0.18.04.1) ...
Processing triggers for ureadahead (0.100.0-21) ...
tharun@server2-west:~$
```

From the lab exercise, we learned how to create the inbound port rule so that the server can be made accessible to the public. To do that, port 80 for HTTP should be opened on all four servers. After selecting the inbound port rule and make the destination port 80 and add. It would just take few seconds in the backend and the port number will be added and below you can see the webpage of that server. It’s good to know that, the lower the priority number of a port, the higher it takes precedence.

Home > Virtual machines > server1-west

Virtual machines

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+ Add ▾ ⌚ Reservations ▾ ...

Try the new virtual machine resource browser! This experience is faster and has improved sorting and filtering capabilities. Please note that the new experience will not show classic virtual machines and does not include support for some columns such as maintenance status.

Filter by name...

- ☐ Name ↑↓
- ☐ server1-east ...
- ☐ server1-west ...
- ☐ server2-east ...
- ☐ server2-west ...

server1-west | Networking

Virtual machine

Search (Ctrl+/) << Attach network interface Detach network interface

Overview
Activity log
Access control (IAM)
Tags
Diagnose and solve problems

Settings

- Networking
- Connect
- Disks
- Size
- Security
- Advisor recommendations

server1-west558

IP configuration ⓘ

ipconfig1 (Primary) ▾

Network Interface: server1-west558 Effective security rules Topology

Virtual network/subnet: azprojUSW-vnet/default NIC Public IP: **104.42.38.136**
NIC Private IP: **10.0.0.4** Accelerated networking: **Disabled**

Inbound port rules Outbound port rules Application security groups Load balancing

Network security group **server1-west-nsg** (attached to network interface: **server1-west558**)
Impacts 0 subnets, 1 network interfaces

Add inbound port rule

Priority	Name	Port	Protocol	Source
300	SSH	22	TCP	Any
65000	AllowVnetInBound	Any	Any	VirtualNetv

Add inbound security rule

server1-west-nsg

Basic

Source * ⓘ

Any

Source port ranges * ⓘ

*

Destination * ⓘ

Any

Destination port ranges * ⓘ

80

Protocol *

Any TCP UDP ICMP

Action *

Allow Deny

Add

← → ↻ 🔒 Not secure | 104.42.38.136

Apps ★ Bookmarks Outlook.com - thar... Justice League Arch... Technology Python Excel Tutori... Welcome to Python... Kairos | Focusing th... Other bookmarks

Apache2 Ubuntu Default Page

ubuntu

It works!

This is the default welcome page used to test the correct operation of the Apache2 server after installation on Ubuntu systems. It is based on the equivalent page on Debian, from which the Ubuntu Apache packaging is derived. If you can read this page, it means that the Apache HTTP server installed at this site is working properly. You should **replace this file** (located at `/var/www/html/index.html`) before continuing to operate your HTTP server.

If you are a normal user of this web site and don't know what this page is about, this probably means that the site is currently unavailable due to maintenance. If the problem persists, please contact the site's administrator.

Configuration Overview

Ubuntu's Apache2 default configuration is different from the upstream default configuration, and split into several files optimized for interaction with Ubuntu tools. The configuration system is **fully documented in `/usr/share/doc/apache2/README.Debian.gz`**. Refer to this for the full documentation. Documentation for the web server itself can be found by accessing the **manual** if the `apache2-doc` package was installed on this server.

The configuration layout for an Apache2 web server installation on Ubuntu systems is as follows:

```
/etc/apache2/
|-- apache2.conf
/   |-- ports.conf
|-- mods-enabled
/   |-- *.load
```

Here to replace the webpage, first I deleted the index.html and replaced it with a new file. Below are the following commands which are to be followed.

```
Azure Cloud Shell

Bash ▾ ⏻ ? ⚙️ 📄 📁 {} 📄

tharun@server2-west:~$ cd /var/www/html
tharun@server2-west:/var/www/html$ sudo rm index.html
tharun@server2-west:/var/www/html$ sudo nano index.html
```

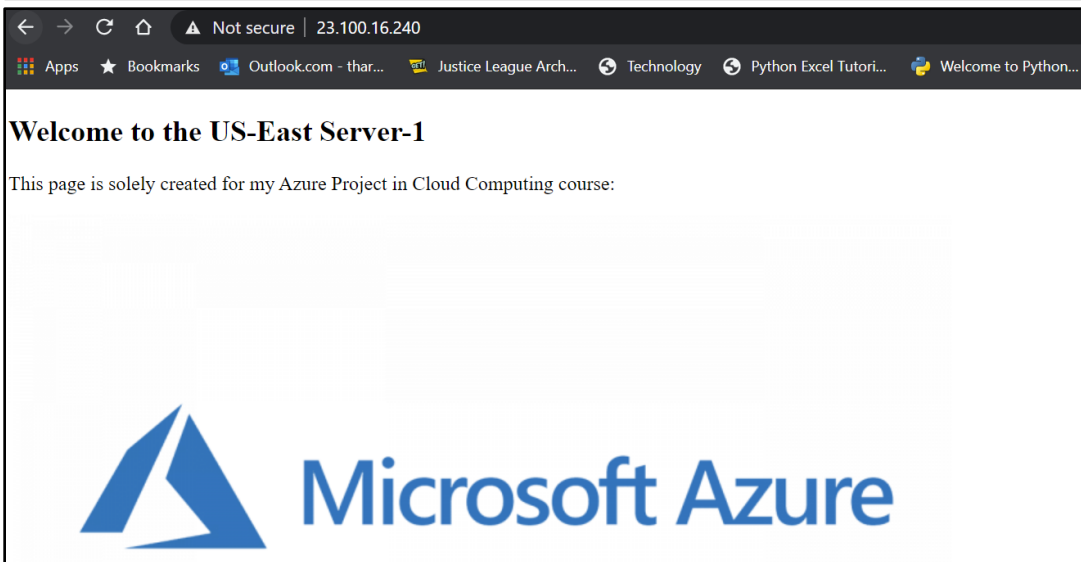
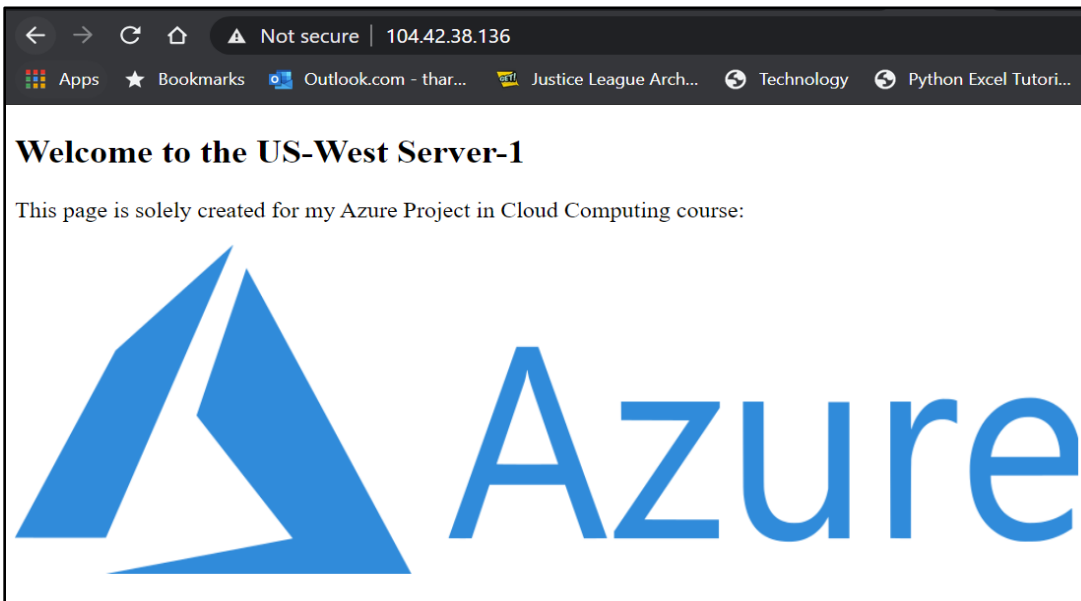
Firstly, I went into the directory in which the index.html file is in. The 'rm' command removes the file. The sudo nano is like a notepad to edit or create a file. I have replaced the index.html file with a simple HTML code and my east and west servers are up as shown in the below snaps.

```
Bash
GNU nano 2.9.3 index.html

<!DOCTYPE html>
<html>
<body>

<h2>Welcome to the US-West Server-2</h2>
<p>This page is solely created for my Azure Project in Cloud Computing course:</p>


</body>
</html>
```



Similarly, the US-West Server2 and US-East Server 2 are also have their index files updated.

Deploying Application Gateways:

The load balancer which I'm going to deploy is through an application gateway. While creating an application gateway, I have decided to go with the resource group where my west servers are running and the virtual network is selected accordingly. The subnet shouldn't have any other resources. So, to that go to virtual networks and select add a subnet to the virtual network choosing the address range accordingly. I have changed the address space from 10.0.0.0/24 to 10.0.0.0/8. I followed similar steps for East servers too. It did take a lot of time for me to figure out the address spaces.

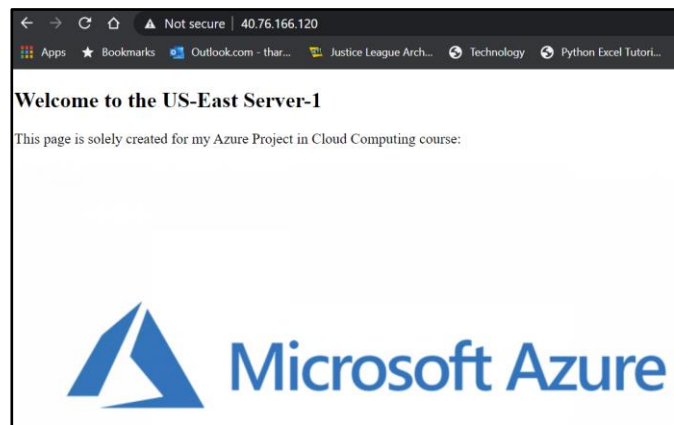
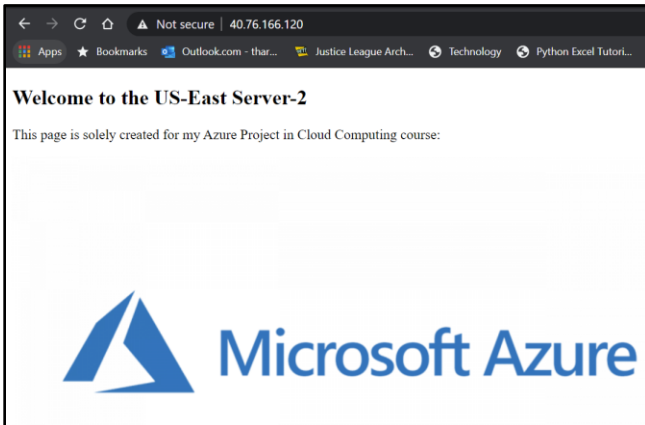
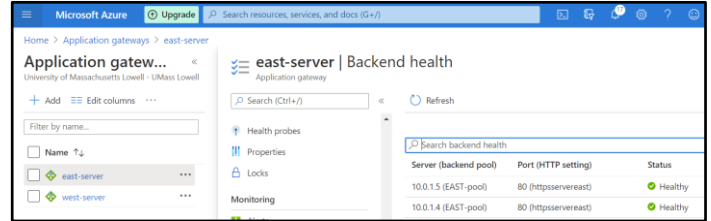
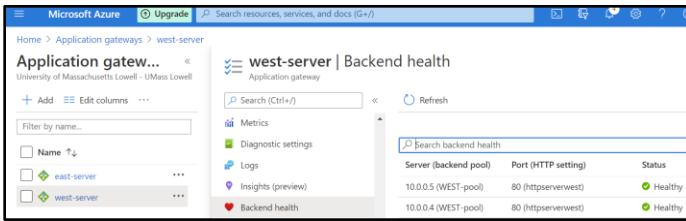
The screenshot shows the 'Create application gateway' form in the Microsoft Azure portal. The form is titled 'Create application gateway' and is located under 'Home > Application gateways >'. It has several input fields and a dropdown menu. The 'Minimum scale units' field is set to 0, and the 'Maximum scale units' field is set to 10. The 'Availability zone' dropdown is set to 'None'. The 'HTTP2' checkbox is checked, and the 'Enabled' radio button is selected. The 'Configure virtual network' section has a 'Virtual network' dropdown set to 'azprojUSW-vnet' and a 'Subnet' dropdown set to 'default (10.0.0.0/24)'. There is a red error message at the bottom: 'Subnet must only have application gateway'.

The screenshot shows the 'Add subnet' form in the Microsoft Azure portal. The form is titled 'Add subnet' and is located under 'Home > Virtual networks > azprojUSW-vnet'. It has several input fields and a dropdown menu. The 'Name' field is empty. The 'Subnet address range' dropdown is set to 'e.g. 10.0.0.0/24'. There are checkboxes for 'Add IPv6 address space', 'NAT gateway', 'Network security group', and 'Route table', all of which are set to 'None'. There is a 'SERVICE ENDPOINTS' section at the bottom. The 'OK' and 'Cancel' buttons are at the bottom right.

After the subnet is added to the application gateway, the front end is always an ip address which is going to hit, and it routes to the backend servers that I have. Also, I have created WEST-pool as the backend and added the virtual machines to it. We should at least specify 1 routing rule for this load balancer for its front and backends. And, after that the load balancer is created and deployed on the virtual network.

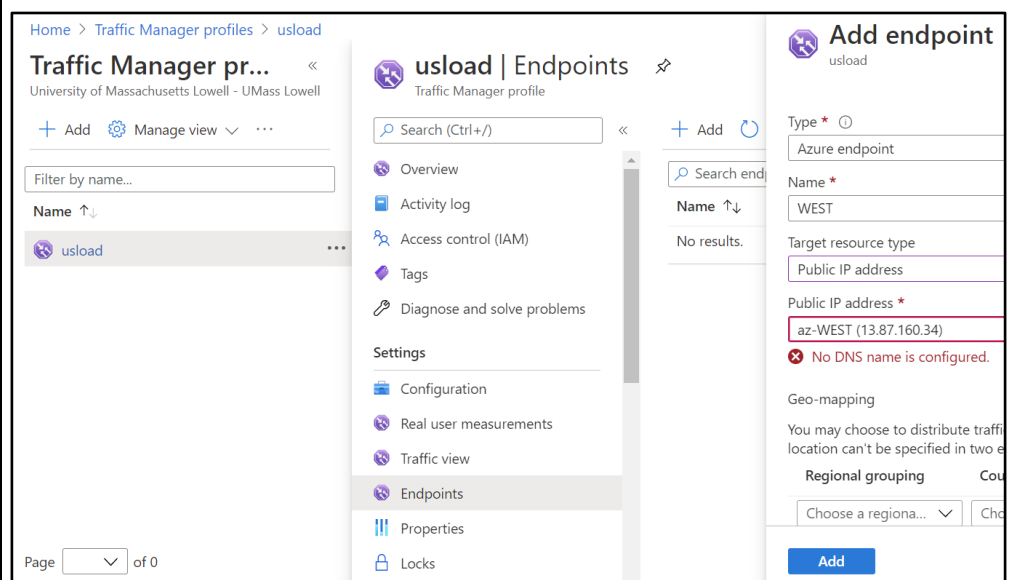
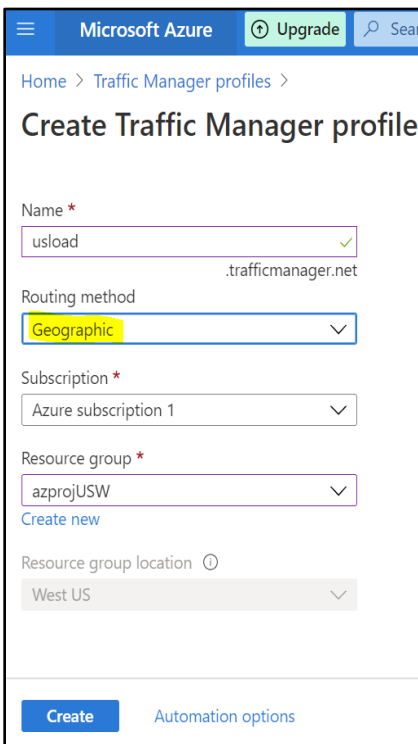
The screenshot shows the 'Add a backend pool' form in the Microsoft Azure portal. The form is titled 'Add a backend pool' and is located under 'Home > Application gateways >'. It has several input fields and a dropdown menu. The 'Name' field is set to 'WEST-pool'. There is a checkbox for 'Add backend pool without targets' which is set to 'No'. The 'Backend targets' section has a table with 2 items. The first item is 'Virtual machine' with the target 'server1-west558'. The second item is 'Virtual machine' with the target 'server2-west309 (10.0.0.5)'. There is a 'Previous' button and a 'Next : Configuration >' button at the bottom left. The 'Add' and 'Cancel' buttons are at the bottom right.

Now, the application gateways are deployed and are running successfully with their respective backend pool od servers. Here, the load balancer automatically redirects between the server pool in each region.

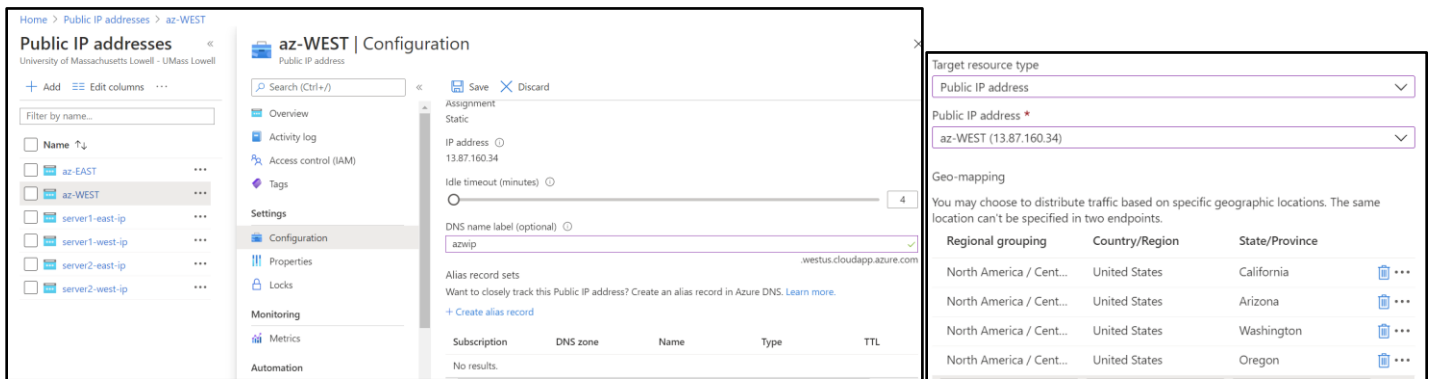


Deploying a Traffic Manager:

I have created a traffic manager based on the geographic location. So, the requests from the users will be handled by the servers which are closest to the user. Now that, the traffic manager is in place, I need to configure the load balancers to the traffic manager by adding endpoints.



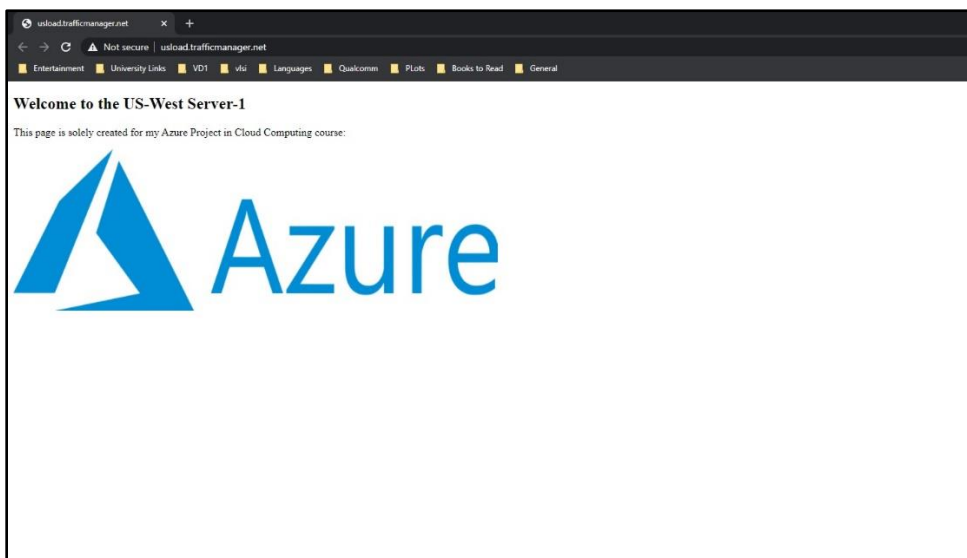
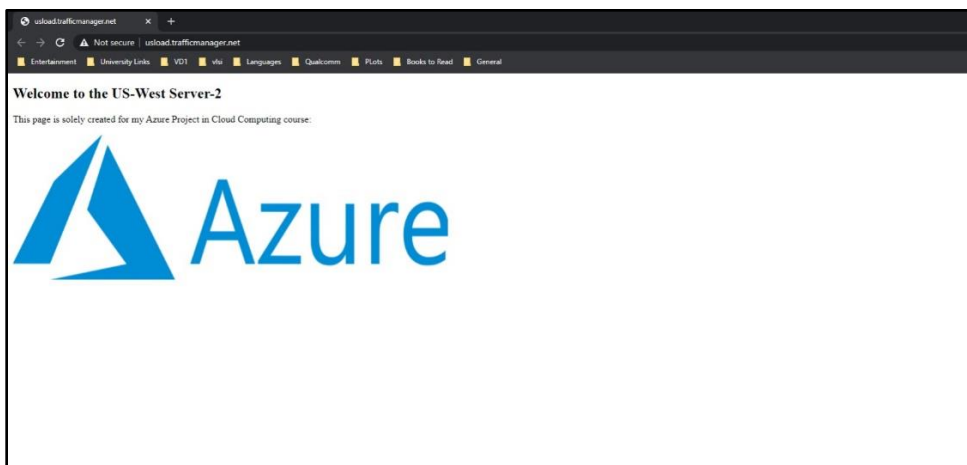
When I tried to add the endpoints, I found out that for the application gateway of west servers, no DNS name was configured. So, I navigated to Public IP addresses and selected the application gateway of the west servers, and configured the DNS name on it.



The screenshot shows the Azure portal interface for configuring a Public IP address. The left sidebar lists the 'Public IP addresses' for the 'az-WEST' resource group, including 'az-EAST', 'az-WEST', and several 'server' endpoints. The main pane shows the 'az-WEST | Configuration' page for a specific Public IP address. The 'DNS name label (optional)' field is set to 'azwip'. The 'Geo-mapping' section provides a table of regional groupings for the United States.

Regional grouping	Country/Region	State/Province
North America / Cent...	United States	California
North America / Cent...	United States	Arizona
North America / Cent...	United States	Washington
North America / Cent...	United States	Oregon

Now, I specified the location based on which the traffic gets distributed and added them to this traffic manager. I am staying near Boston so, my request will not be handled by any server and to verify if it is deployed successfully, I requested my friend who is in California to check out <http://usload.trafficmanager.net> and asked him to share the snaps with me and below are those snaps where you could see that the how the traffic is managed between the pool of servers available at the backend by the load balancer.



DNS Zone:

With the help of www.my.freenom.com I could get a free domain and I have added that to the DNS zone on the azprojUSW resource group and the deployment is successful. Now, I must connect this domain to the DNS zone and then create a DNS zone to configure the traffic manager. There are the name servers associated with this DNS zone and these name servers will be configured on the domain using the management tools on the www.my.freenom.com site. I just entered these name servers and saved the changes on my.freenom site.

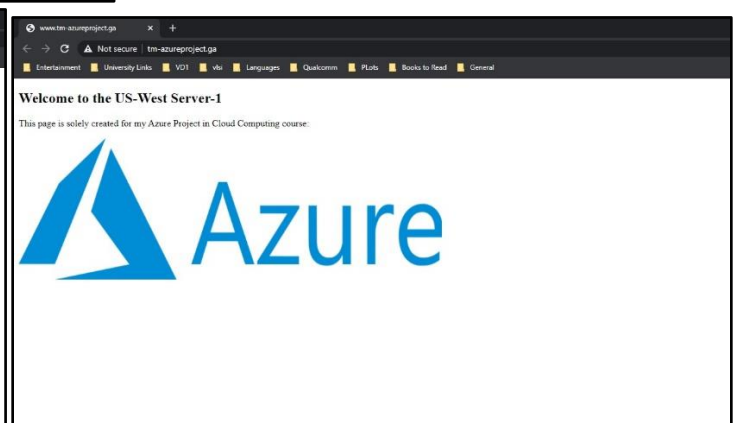
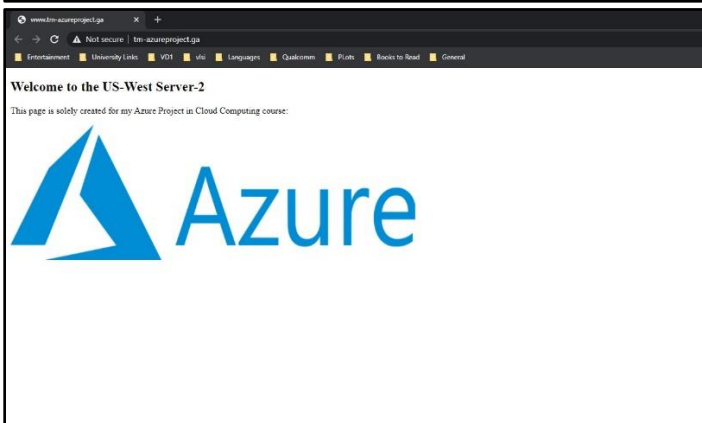
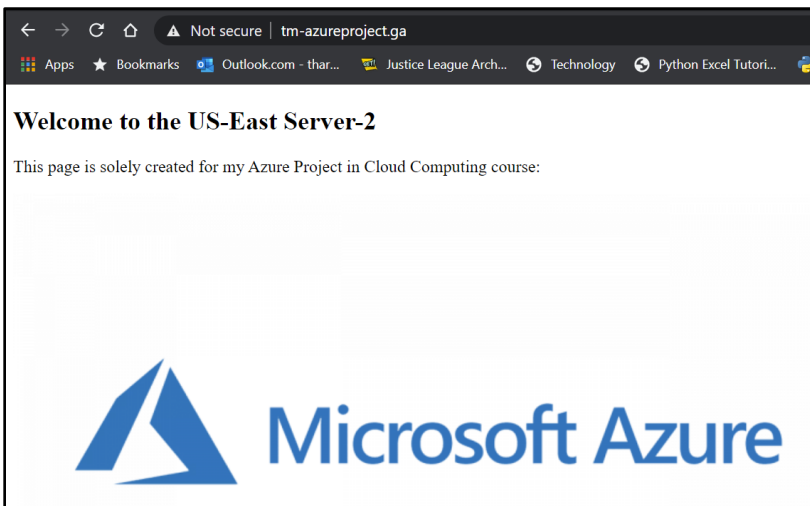
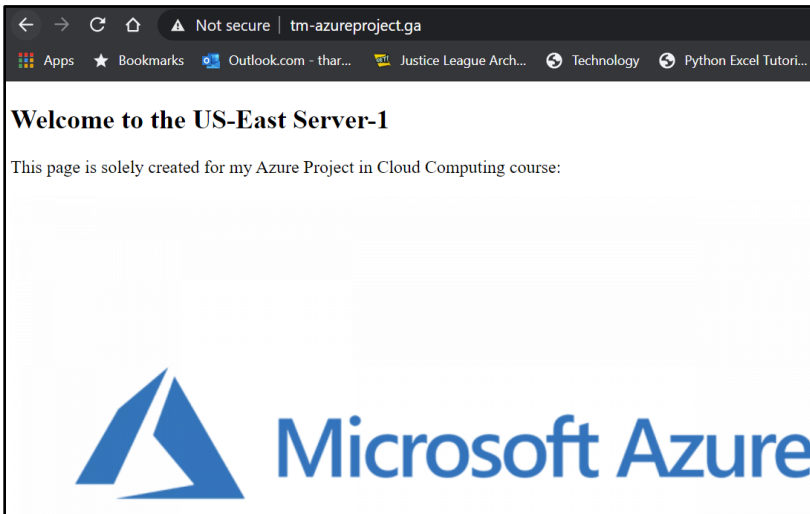
The screenshot shows the Azure portal interface for a DNS zone named 'tm-azureproject.ga'. The left sidebar contains navigation links for Overview, Activity log, Access control (IAM), Tags, Diagnose and solve problems, Settings (Properties, Locks), and Monitoring (Alerts, Metrics). The main content area displays the zone's details, including its ID and a list of name servers: ns1-02.azure-dns.com, ns2-02.azure-dns.net, ns3-02.azure-dns.org, and ns4-02.azure-dns.info. Below this, there is a table of record sets. The table has columns for Name, Type, TTL, and Value. Two record sets are visible: an '@' record of type NS with a TTL of 172800, and an '@' record of type SOA with a TTL of 3600. The SOA record's value includes email, host, refresh, retry, expire, and minimum TTL values.

The screenshot shows the Freenom website's 'Managing tm-azureproject.ga' page. The page has a header with 'Information', 'Upgrade', 'Management Tools', and 'Manage Freenom DNS'. The 'Nameservers' section is active, showing a list of default nameservers (Freenom Nameservers) and a section for custom nameservers. Below this, there are three input fields for 'Nameserver 1', 'Nameserver 2', and 'Nameserver 3'. The page also includes a note about changing domain names and a warning about propagation time.

Now, I need to point my DNS to my traffic manager. So, I added a recordset with the name www. There are many choices available under type and I chose CNAME. I followed the procedure on my east load balancer – Added geographic locations to route traffic

The image contains two screenshots from the Microsoft Azure portal. The left screenshot shows the 'Add record set' dialog for the domain 'tm-azureproject.ga'. The 'Name' field is set to 'www', and the 'Type' is set to 'CNAME'. The 'Alias record set' is set to 'Yes', and the 'Alias type' is set to 'Azure resource'. The 'Choose a subscription' dropdown is set to 'Azure subscription 1', and the 'Azure resource' dropdown is set to 'usload'. The 'TTL' is set to '1' and the 'TTL unit' is set to 'Hours'. The right screenshot shows the 'EAST' traffic manager profile for the 'usload' resource. It displays a list of geographic locations for routing traffic, including North America / Central America / Caribbean, United States, and various states like Massachusetts, New Jersey, Illinois, Texas, New Hampshire, New York, and North Carolina. A '+ Add geo-mapping' button is visible at the bottom.

The traffic manager has both the region endpoints and now users from the above-mentioned states in east/west regions can access www.tm-azureproject.ga and see that the user requests are being handled by the servers which are closest to them.



Recovery System Service:

Recovery Service Vault (RSV) is a storage entity in Azure that houses data. You can use RSV to hold backup data, recovery points, workloads, and configuration information for virtual machines. I have created a new backup policy with weekly frequency for both the regions. So now all the servers are having a backup and I can restore if the VMs crash at any point in time in the future.

Create Recovery Services vault

Preview

Summary

Basics

Subscription	Azure subscription 1
Resource group	azprojUSE
Vault name	servetvlt
Region	East US

Backup policy

Policy name * ⓘ
Eastbackup ✓

Backup schedule

Frequency *	Days *	Time *	Timezone *
Weekly ✓	Sunday ✓	6:00 AM ✓	(UTC-05:00) Eastern Time (US ... ✓

Instant Restore ⓘ

Retain instant recovery snapshot(s) for

RETENT	Day(s) ⓘ
5 ✓	

Retention range

☐ Retention of daily backup point.

Not Configured

☒ Retention of weekly backup point.

OK

Home > servetvlt > Backup Items (Azure Virtual Machine) >

server1-west

Backup Item

[Backup now](#) [Restore VM](#) [File Recovery](#) [Stop backup](#) [Resume backup](#) [Delete backup data](#) [Restore to Secondary Region](#) [Undelete](#)

Alerts and Jobs View all Alerts (last 24 hours) View all Jobs (last 24 hours)	Backup status Backup Pre-Check ✓ Passed Last backup status ⚠ Warning(Initial backup pending)	Summary Recovery services vault servetvlt Backup policy servetvlt Oldest restore point -
--	---	--

Restore points

This list is filtered for last 30 days of restore points. To recover from restore point older than 30 days, [click here](#).

CRASH CONSISTENT	APPLICATION CONSISTENT	FILE-SYSTEM CONSISTENT
0	0	0
Time	Consistency	Recovery Type

No restore points available.

Monitoring and Performance Alerts:

The creation of alert rules will sometimes fail since the subscription might not be registered to Microsoft.insights resource provider. So, to register them Go to All services and search for the subscription and then navigate to the resource provider and check if they are registered and if they are not then register them.

Subscriptions
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View list of subscriptions for which you have role-based access control (RBAC) permissions to manage Azure resources. To view subscriptions for which you have billing access, [click here](#). Showing subscriptions in University of Massachusetts Lowell - UMass Lowell directory. Don't see a subscription? [Switch directories](#)

My role: 8 selected Status: 3 selected [Apply](#)

Showing 1 of 1 subscriptions ☒ global
Show only subscriptions selected in the subscriptions filter

Subscription name:

Azure subscription 1 | Resource providers

Search (Ctrl+/) Re-register Unregister Refresh

Filter by name...

Provider	Status
Microsoft.Storage	Registered
Microsoft.Advisor	Registered
Microsoft.Security	Registered
Microsoft.Compute	Registered
Microsoft.Network	Registered
Microsoft.ResourceHealth	Registered
Microsoft.RecoveryServices	Registered

To create alerts on the resource which I have created, I had to make sure that those resources are being registered to the default dashboard that azure provides helps with a lot of insights about the resources I used. I have enabled the azure monitor on all 4 VMs in two regions.

Connections [✦](#)

Azure Monitor

[Workbooks](#) [Edit](#) [Print](#) [Refresh](#) [Share](#) [Feedback](#)

Select a row from the table below to view connection details for that entry.

Search

Name	Type	MaliciousConnections	Responses	MaxLinks	LinksFailed	AverageR	TotalByte	TotalByte
Overall	Overall	1 Malicious Connection	3.083K	4	0	362.877ms	1.552MiB	719.524KiB
server2-west	Computer	1 Malicious Connection	809	4	0	365.007ms	435.936KiB	194.131KiB
server1-west	Computer	No Malicious Connections	887	3	0	420.798ms	350.886KiB	165.877KiB
server2-east	Computer	No Malicious Connections	1.123K	2	0	400.896ms	561.544KiB	259.294KiB
server1-east	Computer	No Malicious Connections	264	1	0	22.727μs	240.416KiB	100.223KiB

Insights

[Refresh](#) [Provide Feedback](#)

Monitored (0) **Not monitored (4)** [Workspace configuration](#) [Other onboarding options](#)

Name	Monitor Coverage	Workspace
Azure subscription 1	4 of 4	
azprojuse	2 of 2	
server1-east	Enabling - Waiting for data (Why?)	defaultworkspace-7de897ca-40ad-4df9-b113-bf5da...
server2-east	Enabling - Waiting for data (Why?)	defaultworkspace-7de897ca-40ad-4df9-b113-bf5da...
azprojusw	2 of 2	
server1-west	Enabling - Enabling (Why?)	
server2-west	Enabling - Enabling (Why?)	

I've created an application insight east servers to monitor the VMs on the east region and created alerts on them. The fascinating thing about Azure is it's cost-friendly. You have to pay for what services you use. The cost to put set up these rules on the VMs are very economical, just \$0.1 per month.

eastservers | Live Metrics

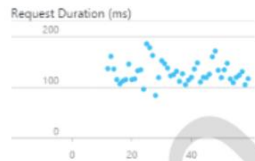
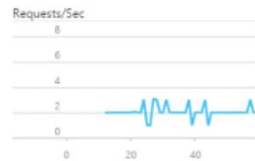
Application Insights

[Application map](#)[Smart Detection](#)[Live Metrics](#)[Search](#)[Availability](#)[Failures](#)[Performance](#)[Troubleshooting guides \(previ...](#)

Monitoring

[Alerts](#)[Metrics](#)[Diagnostic settings](#)

Incoming Requests



Outgoing Requests



Server Health



Create alert rule

Rules management



Configure when the alert rule should trigger by selecting a signal and defining its logic.

Condition name	Time series monitored	Estimated monthly cost (USD)
✓ Whenever the average process cpu is greater than 10 %	1	\$ 0.10
Select condition	1	Total \$ 0.10

Action group

Send notifications or invoke actions when the alert rule triggers, by selecting or creating a new action group. [Learn more](#)

Action group name	Contains actions
Monitoring	
Select action group	

[Create alert rule](#)

Create alert rule

Rules management

[Edit resource](#)

Condition

Configure when the alert rule should trigger by selecting a signal and defining its logic.

Condition name	Time series monitored	Estimated monthly cost (USD)
✓ Whenever the average availability is less than 99.99 %	1	\$ 0.10
Select condition	1	Total \$ 0.10

Action group

Send notifications or invoke actions when the alert rule triggers, by selecting or creating a new action group. [Learn more](#)

Action group name	Contains actions
-------------------	------------------

[Create alert rule](#)

Cost Alerts, Billing and Budgets:

Azure has this amazing feature of creating the budgets. It helps in the easy track of the expenses we invest in this case, the free credits that are left to consume. A monthly budget alert has been created and so as the cost alert with the condition is set to 25% and I receive an email notification accordingly.

Search (Ctrl+/) <<

✓ Create a budget ✓ Set alerts

Configure alert conditions and send email notifications based on your spend.

* Alert conditions

% Of budget	Amount
25 ✓	25
Enter %	-

* Alert recipients (email)

Alert recipients (email)

Previous Create

Conclusion:

It was an amazing experience working on the Azure cloud platform as part of this project. The azure interface was very intuitive, and I also found the integrated PowerShell novel and helpful. My weekly lab exercise did come in handy while creating the project. The Project Papers shared by Professor Bell each week also helped me big time. Nonetheless, there are plenty of resources and guides under every section and even if one is completely new to this platform, it is easy to learn as we go.

From a project perspective, I was very happy with the fact that I was able to achieve what I intend to do, especially being able to set up a traffic manager, gateways in two different regions. So, I designed, implemented, deployed, and monitored a website which in the future can be developed into an e-commerce site and the user request could be processed with lesser latency as the requests will be addressed by the servers closest to the user. Personally, for me, it's a highly gratifying experience to have been start-up with the Azure platform.