App Modernization Labs
Azure Kubernetes Service

Author: Francis S Nazareth

Cloud Solutions Architect, Azure App Dev, Microsoft Qatar

fnazaret@microsoft.com / +974 33134296

Contents

Pre-Requisites

1. You should have owner access to a resource group (where AKS, virtual network, and other resources will be created).
2. GitHub account

1. Create Resources

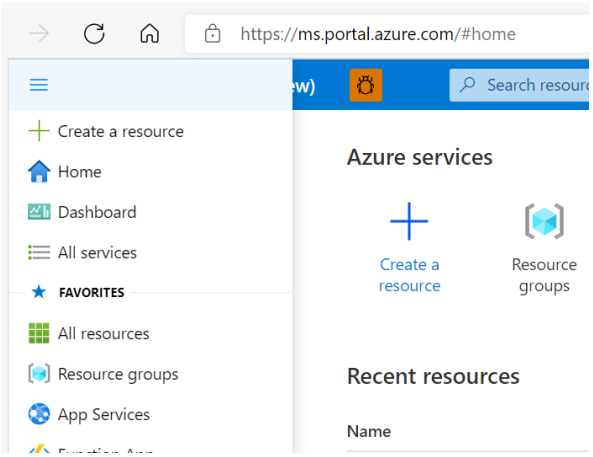
In this lab, you will create a resource group in Azure, virtual network and subnets in Azure, Azure Kubernetes Service and an instance of Azure Container Registry.

Steps:

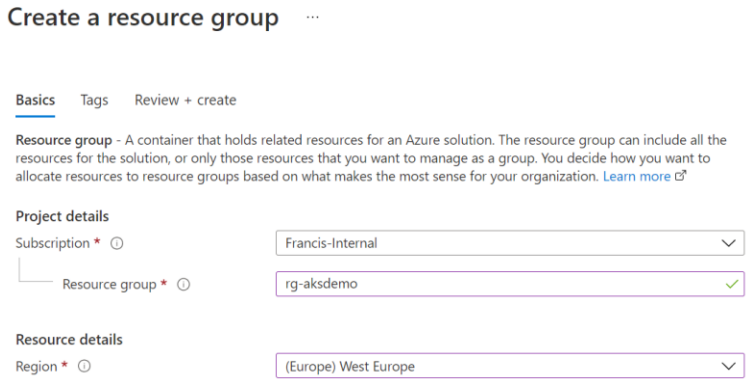
Sign up / Log in to Azure Portal.
http://portal.azure.com

1.1 Create a resource group

From the menu on top left, select "Resource Groups". Click "+Create".



Specify a name for the resource group, and specify a location (for example, West Europe).



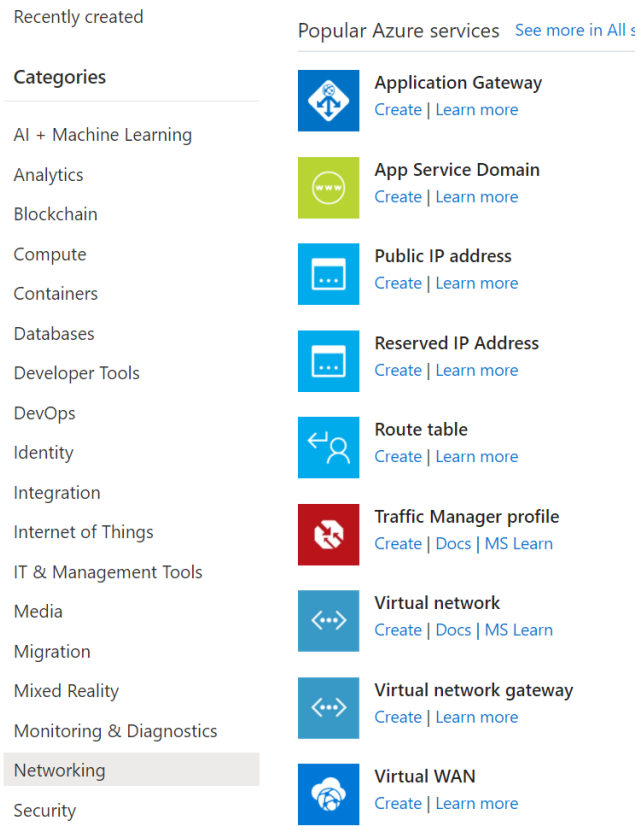
Click "Review & Create", followed by "Create". The resource group should be created after this step.

1.2 Create a virtual network and subnets

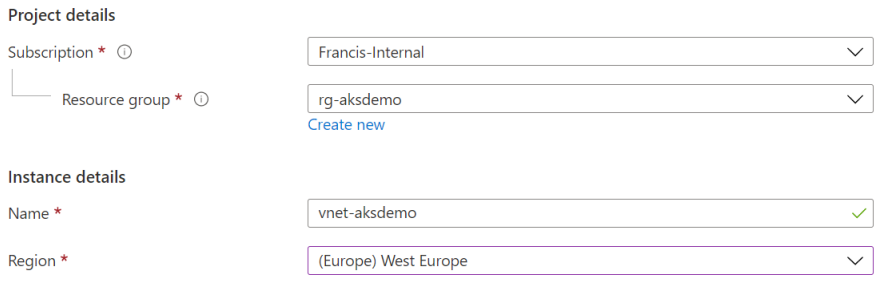
(Note: We are creating a virtual network and subnet to use the Azure CNI network plugin in Azure Kubernetes Service. Azure CNI network plugin offers several advantages over Kubenet, the second network plugin option in AKS).

Go to the resource group (click on the resource group name)
Click on +Create

From the menu, select "Networking"
Under "Virtual Networks", click "Create".



Provide a name for the resource (For example, vnet-aksdemo). Choose the region as same as the resource group's region. And Click "Next: IP Addresses>".

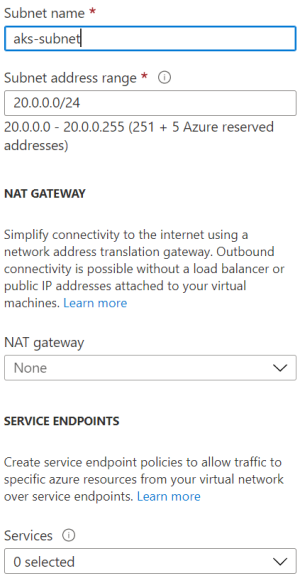


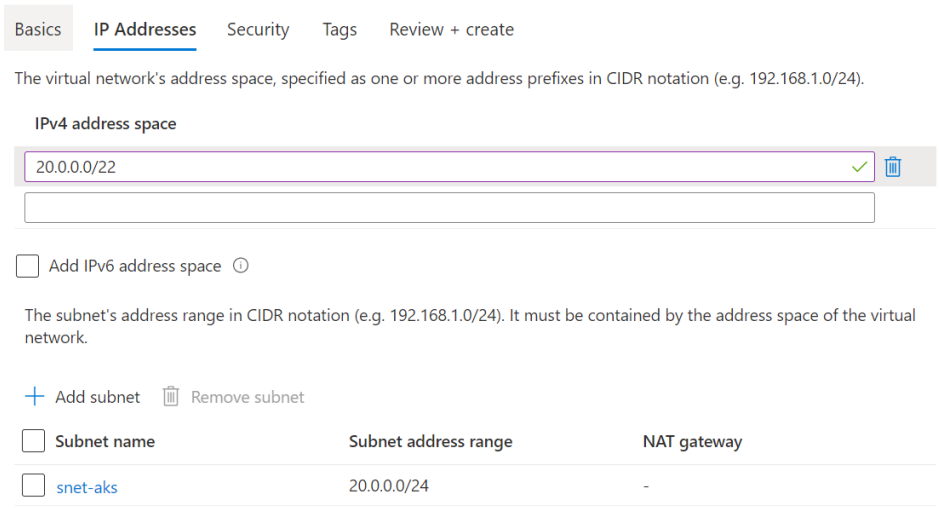
In the IP addresses tab, delete the default IPV4 Address Space.
Add an IPV4 address space. For example: 20.0.0.0/22

click + Add Subnet

- Specify a name for the subnet: snet-aks
- Specify the IP address range: 20.0.0.0/24

Click “Add” to add the subnet

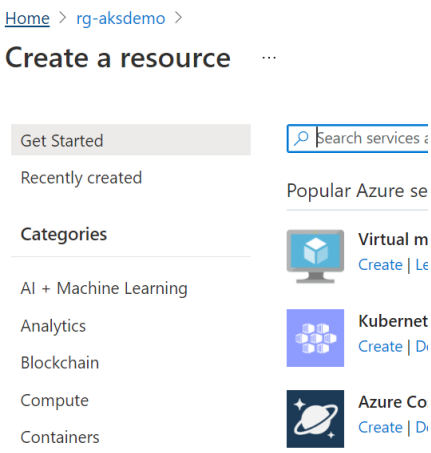




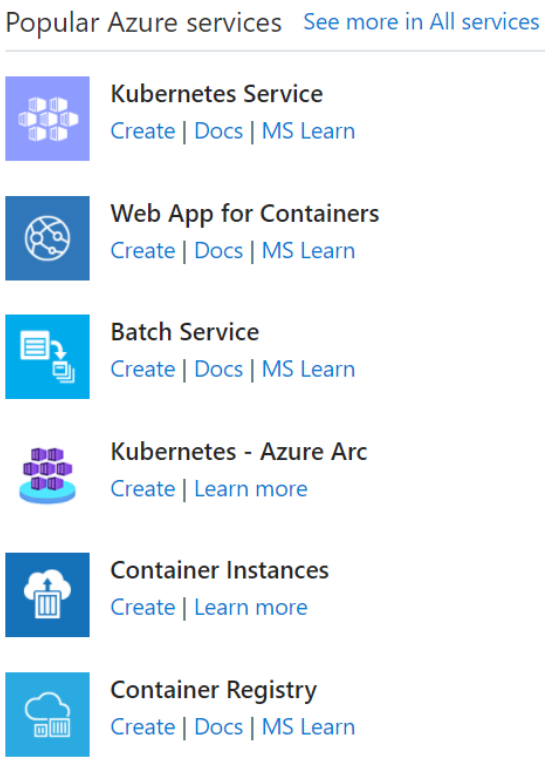
Click “Review & Create”, and “Create” to create the virtual network with subnets.

1.3 Create Azure Container Registry

Go to the resource group (click on the resource group name)
Click on +Create
From the menu, select “Containers”



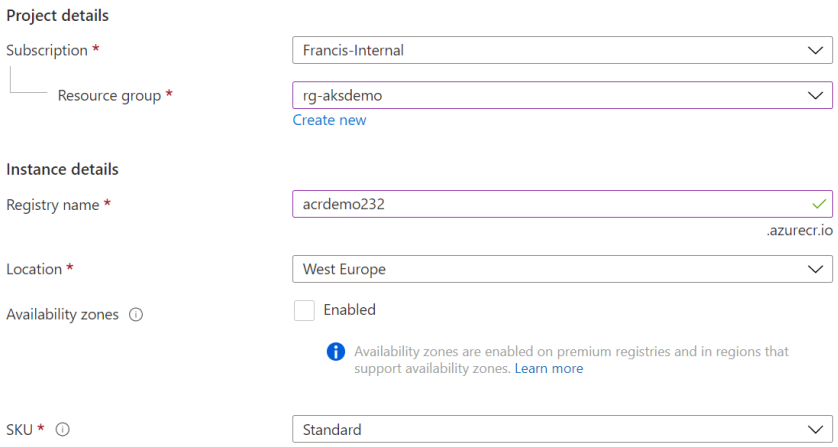
In the list of items, under "Container Registry", click on Create



Specify a unique name for the container registry (for example, acrdemo followed by few random numbers). Please don't use any capital letters in container registry name.

Select the region (select the same region of resource group).

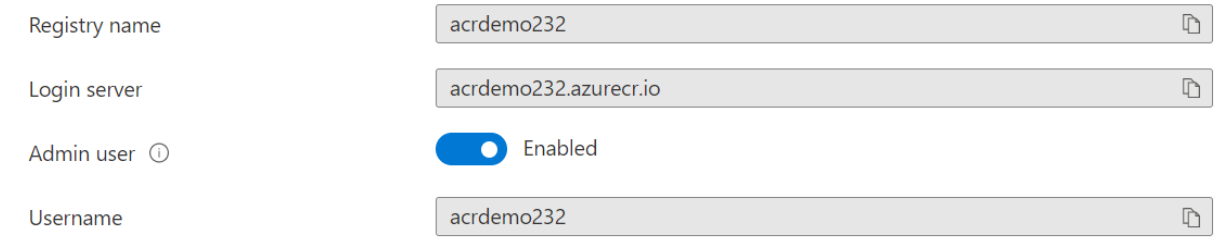
Leave everything else to defaults and click "Review & Create" followed by "Create".



Enable admin access to the container registry:

Open the container registry that got created, and in the left menu, select Settings -> Access Keys.

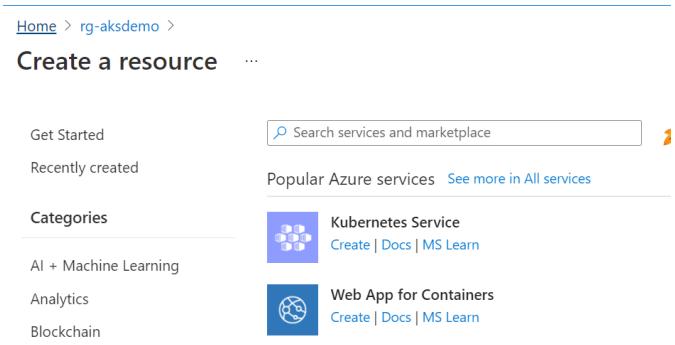
Toggle "Admin User" to Enabled.



Note: Please explore other options in Azure Container Registry screen, such as geo-replication.

1.4 Create Azure Kubernetes Service instance.

Go to the resource group (click on the resource group name)
Click on +Create
From the menu, select "Containers"
Under Kubernetes Service, click "Create"



Provide a name for the cluster (for example, aks-demo)

Select the resource group (that you created in previous step)

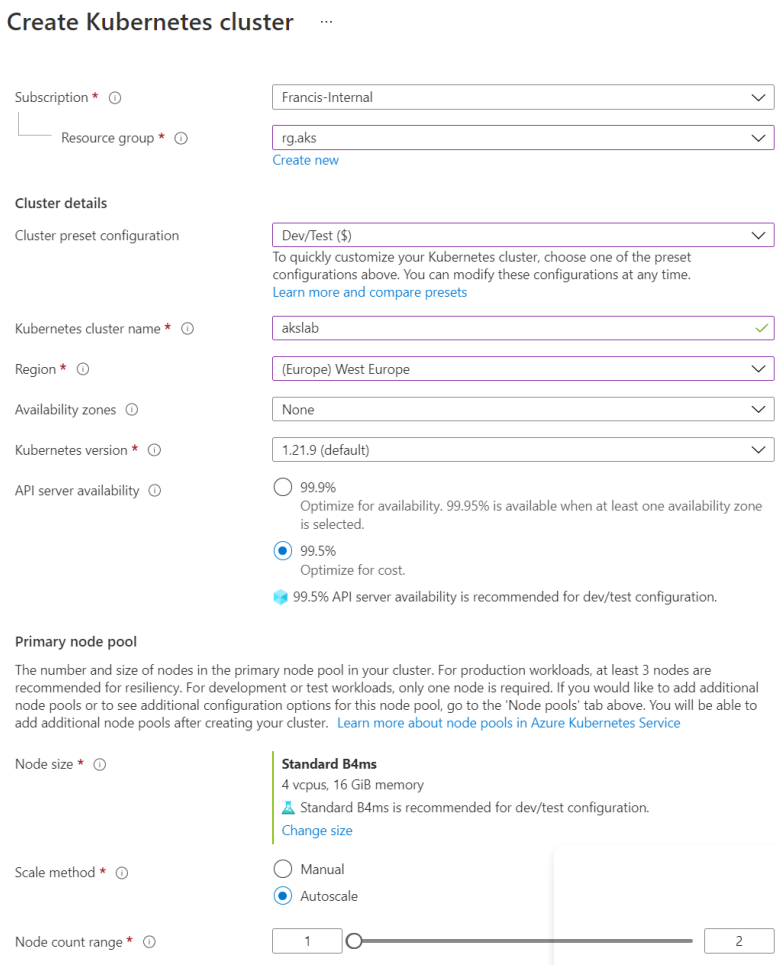
In the cluster details, in cluster pre-set configuration select Dev/Test ($).

Provide a name for the kubernetes cluster (for example, akslab)

Select a region for the cluster (same as virtual network / resource group).

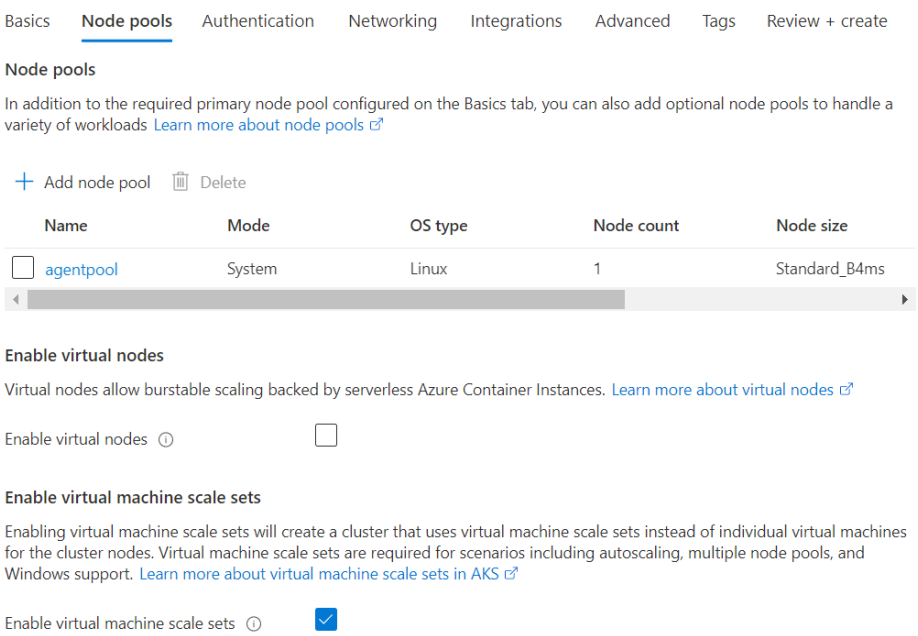
Leave the defaults for availability zone, kubernetes version, and API server availability.

For scale method, select “Auto Scale”. Select minimum as 1 and maximum as 2.



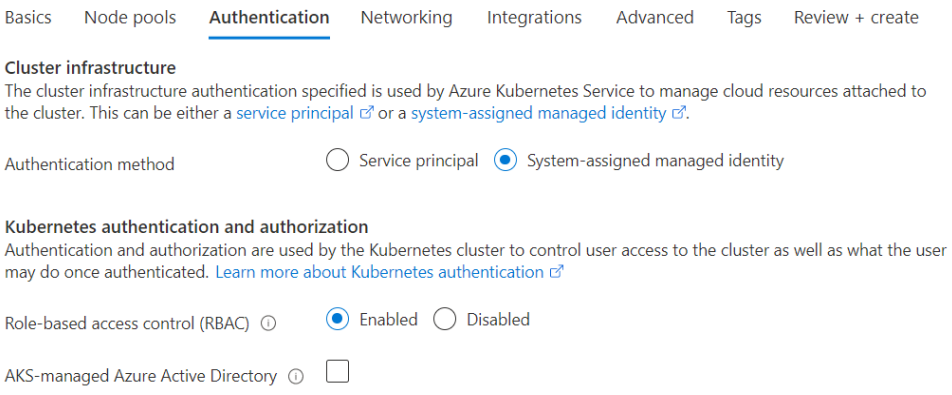
Click “Next > Node Pools”

In the Node Pools screen, leave the defaults for node pools.



Click "Next > Authentication"

Leave the defaults for authentication.



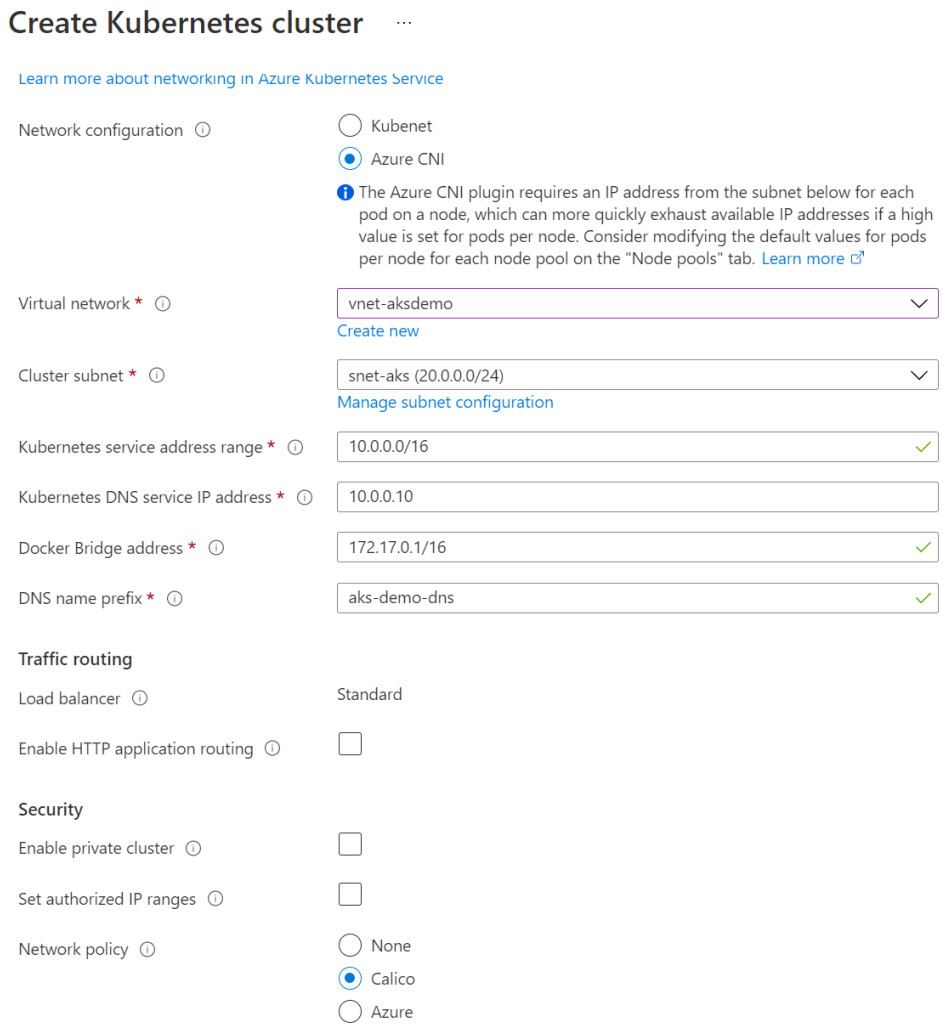
Click "Next: Networking>"

Change the network plugin from kubenet to Azure CNI.

Select the VNET you created earlier.

Select the Subnet you created earlier.

For network policies, select "Calico".

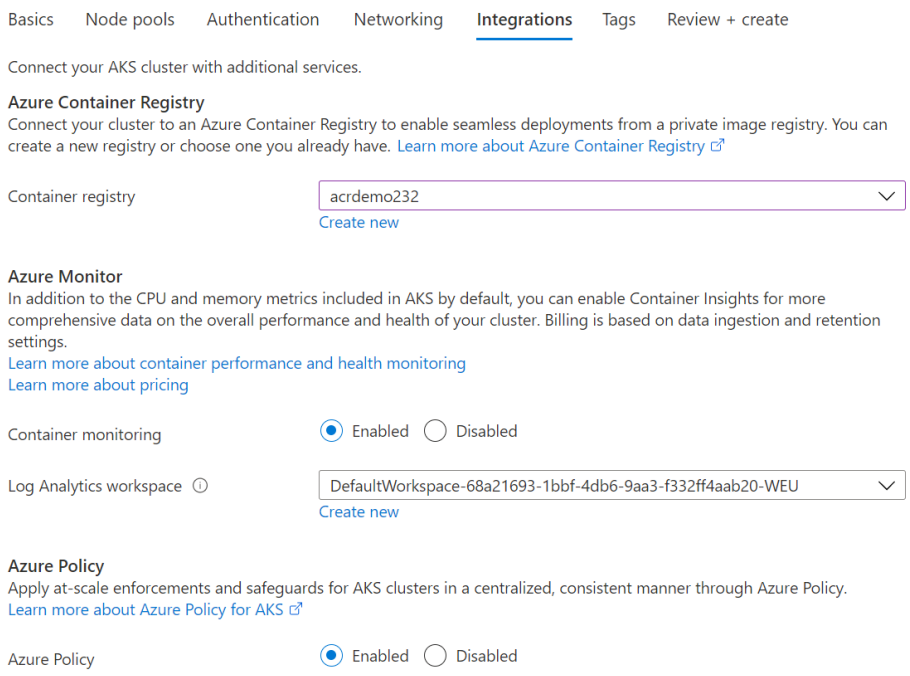


Select "Next: Integrations>"

Select the container registry you created earlier.

Leave container monitoring as enabled.

Select Azure Policy to Enabled.



Click "**Review & Create**", and "**Create**".

2. Create a container application and deploy to AKS

In the following lab, we are going to create a HTML based container application (with NGINX container image as the base layer).

a. On the top blue ribbon, click on "Cloud Shell" button.

Select "Bash" as the environment.

b. Create an HTML file index.html by using the following command:

code index.html

- Copy the following contents to the file

```
<html>
  <body>
    <div align="center">
      <font size="20px">Welcome!</font>
    </div>
  </body>
</html>
```

- Save the file (CTRL + S)
- Exit out of code (CTRL + Q)

c. Create Dockerfile using the following command:

code Dockerfile

- Copy the following contents to Dockerfile

```
FROM nginx

COPY index.html /usr/share/nginx/html
```

Note: Containers follow a layered file system. Each command in the Dockerfile creates a layer. For example, the first line (FROM nginx) starts with the base layer – nginx. If this base image is not available on the local environment, the docker daemon looks for an image named nginx in the public registry (hub.docker.com) and pulls the base image to your environment. The second

line copies the file index.html from local folder to the folder within the container /usr/share/nginx/html/ .. This creates a second layer on top of the base layer (nginx), and builds a new image. (NGINX is a web server, and /usr/share/nginx/html/ is the default directory where NGINX web server looks for HTML files to serve). This image can be named / tagged, and can become the base layer for another image.

- Save the file (CTRL + S)
- Exit out of code (CTRL + Q)

d. Build the docker image and push the docker image to the container registry using the following command

az acr build --registry <<Azure Container Registry Name>> --image mynginx:v1 .

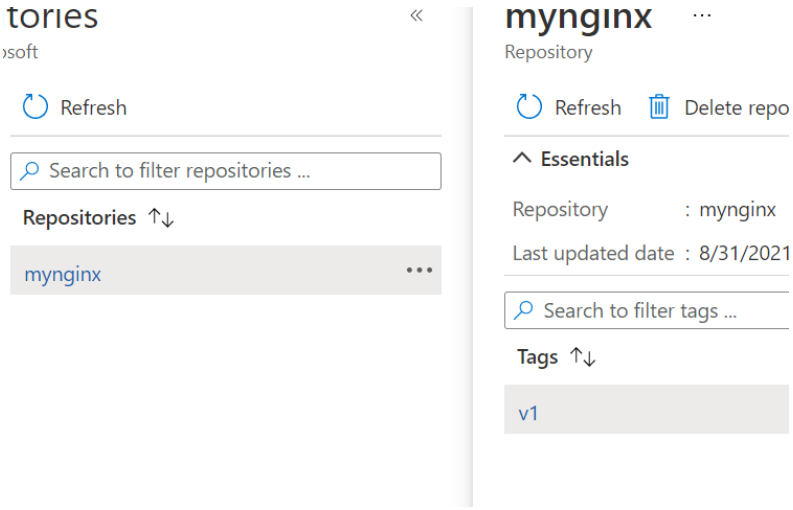
For example,

az acr build --registry acrdemo232 --image mynginx:v1 .

Note: The last parameter (.) denotes the current directory. Please remember to copy the dot (.) as well.

The command az acr build does four things: It looks for a file named Dockerfile in the directory specified (by dot). It builds a container based on the Dockerfile. It tags the Dockerfile with the registry name/image name and tag name (in this case acrdemo232.azurecr.io/mynginx and v1), and it uploads the newly built and tagged image to azure container registry you specified (with the --registry parameter).

e. In the container registry, select "Services -> Repositories". View the container image that was uploaded.

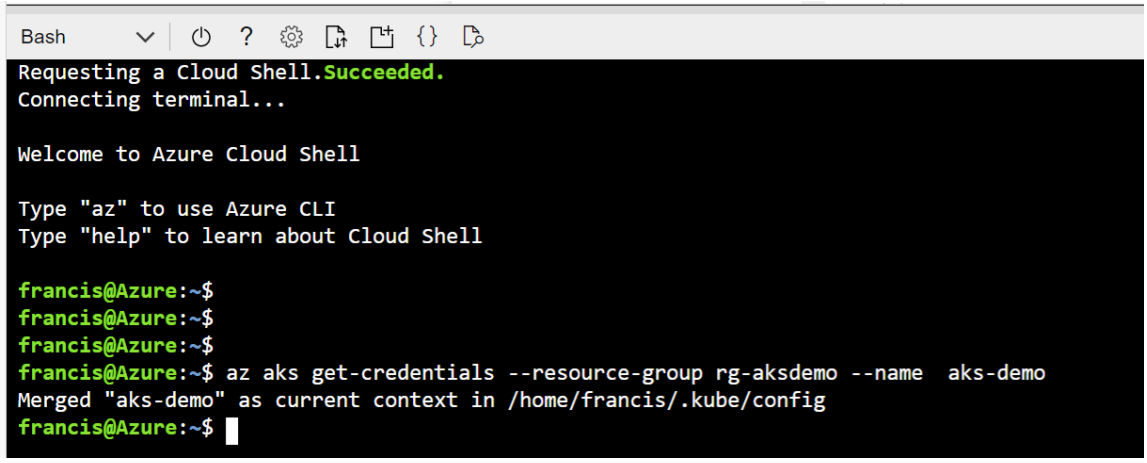


f. In the cloud shell, run the following command (to set the current Kubernetes cluster).

az aks get-credentials --resource-group <<resource group name>> --name <<AKS cluster name>>

For example,

az aks get-credentials --resource-group rg-aksdemo --name aks-demo



g. Check the Kubernetes cluster status

kubectl get nodes -o wide

h. Create a deployment using the container image we uploaded

kubectl create deploy hello-deploy --image <repository name>/<image>:<tag> --replicas=3

For example,

kubectl create deploy hello-deploy --image acrdemo232.azurecr.io/mynginx:v1 --replicas=3

i. Check the pods deployed

kubectl get pods

You should see 3 pods in the running state.

```
francis@Azure:~$ kubectl create deploy hello-deploy --image acrdemo232.azurecr.io/mynginx:v1 --replicas=3
deployment.apps/hello-deploy created
francis@Azure:~$ kubectl get pods
NAME                           READY   STATUS    RESTARTS   AGE
hello-deploy-f6bff5f76-2d9kv   1/1     Running   0          82s
hello-deploy-f6bff5f76-sd5hp   1/1     Running   0          82s
hello-deploy-f6bff5f76-sxm46   1/1     Running   0          82s
```

j. Expose the deployment as a Kubernetes service (a load balancer with a public IP, which distributes the load to the three pods).

kubectl expose deploy hello-deploy --port=80 --target-port=80 --type=LoadBalancer

k. Check the IP address of the service that got created, using the command:

kubectl get services

```
^Cfrancis@Azure:~$ kubectl get services
NAME           TYPE           CLUSTER-IP     EXTERNAL-IP     PORT(S)        AGE
hello-deploy   LoadBalancer   10.0.124.128   51.144.187.93   80:32331/TCP   47s
kubernetes     ClusterIP      10.0.0.1       <none>          443/TCP        16h
```

l. Access the public IP address in a browser

You should see the welcome page rendered in the browser.

Note: We are creating a Kubernetes deployment and a Kubernetes service. The following links may be helpful to understand what are pods, deployments and services.

Pods – pods are the smallest deployable units of computing that you can create and manage in Kubernetes. Pods | Kubernetes

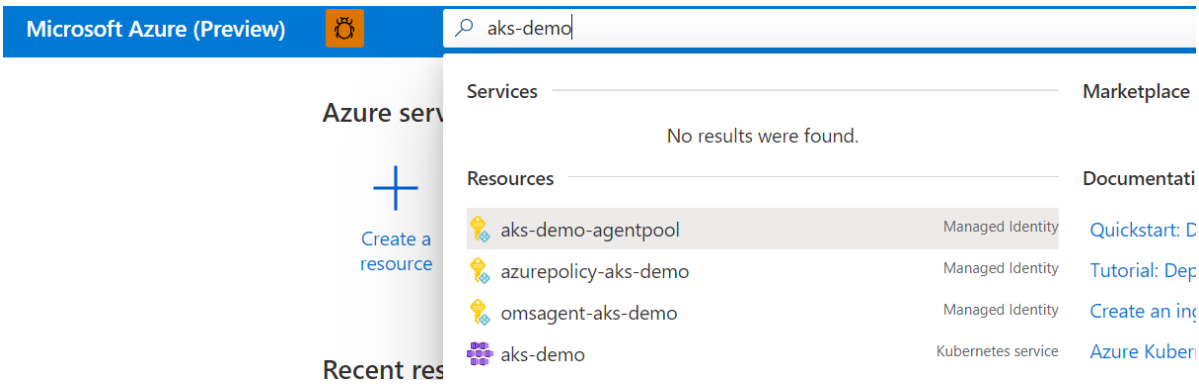
Deployment – Deployment is a collection of identical pods. You can specify the number of replicas pods in the deployment (using the replicas parameter). This is the desired state (desired number of pods) and Kubernetes will try to maintain this pod count within a deployment. Deployments | Kubernetes

Service – Service is way to expose your pods as a network resource. In other words, you can think of the service as a load balancer in front of your deployment (pods) with an internal DNS name for the collection of pods. (The service front ends a deployment. I.e., the service load balances the traffic to the group of pods in a deployment). The service could have an internal or external IP address, and the traffic received on the service will be load balanced to the pods behind the service. Service | Kubernetes

In our case, we created a deployment with three pods. The service we created (using the expose command) creates an Azure Standard Load Balancer, which load balances any requests to the service to the three pods in our deployment.

3. Monitor the cluster using Azure Monitor.

a. Search for the cluster name in the Azure portal's search bar.



b. Click on the Kubernetes service name to go to the cluster view.

c. In the left menu, select Kubernetes resources -> Namespaces

d. Select (click on) the default namespace, and select "View Events".

e. Go back to the cluster view, and select Kubernetes resources -> Workloads

f. Click on the deployment we created (hello-deploy)

g. Select one of the pods, and try deleting the pod.

(Please remember that we specified the desired number of pods through --replicas parameter when we created the deployment. If one of the pods gets killed / deleted, Kubernetes will automatically clone the pods to maintain the replica count we specified. In other words, Kubernetes is self-healing).

h. While on the deployments screen, on the left menu, view events
i. While on the deployments screen, on the left menu, select "Insights".
j. Expand the controller name to see the container details.

k. Go back to the cluster view, and select Kubernetes resources -> Services and ingresses

l. View the details of the service we created (hello-deploy)
Please observe the cluster IP, external IP, and the ports / pods

m. Go back to the cluster view, and select Monitoring -> Insights
Observe the following tabs:

- Cluster

- Reports -> Resource Monitoring -> Deployments
- Nodes
- Controllers (observe the hello-deploy controller)
- Containers (observe the mynginx containers)

n. Go back to the cluster view, and select "Advisor Recommendations"

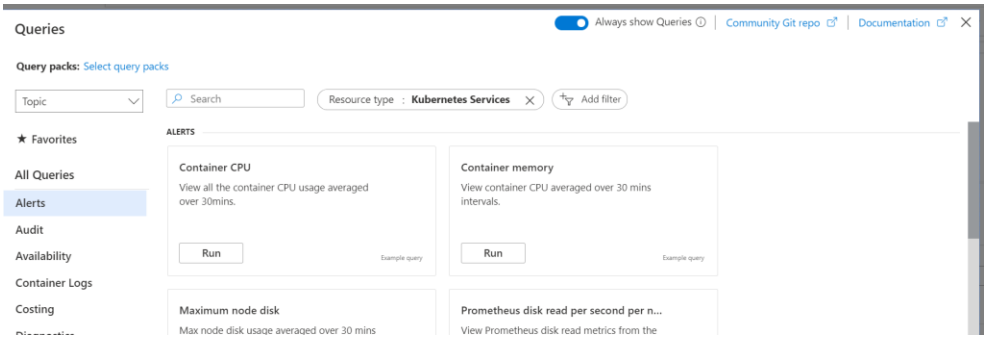
o. Go back to cluster view, and select Monitoring -> Metrics

For the metric, select "CPU usage millicores", and observe the graph.

p. Go back to the cluster view, and select Monitoring -> Alerts
   - Click "+New Alert Rule"
   - For the condition, click "Add condition" and select "CPU Usage Percentage"
   - On the alert logic, select the threshold value of 70
   - Explore the action group, etc. But don't create the alert rule.

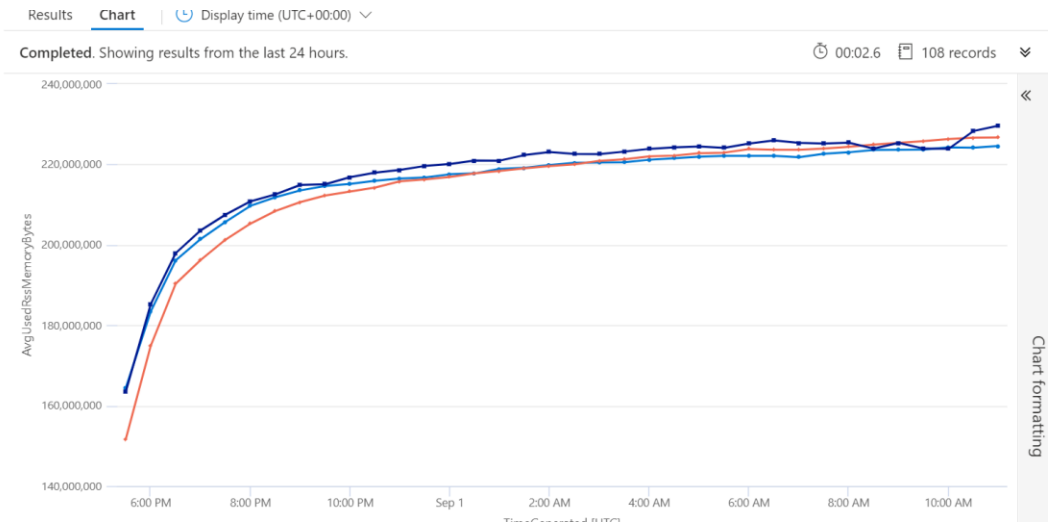
q. Go back to cluster view, and select Monitoring -> Logs

Click on Container Memory -> Run



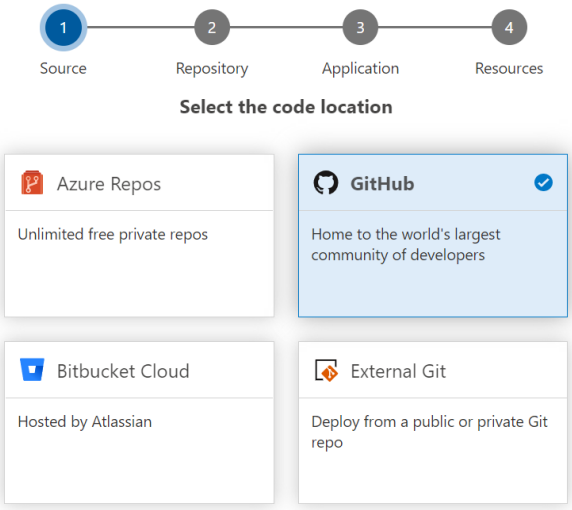
For the query results, select "Chart".

You should see a graph of container memory usage

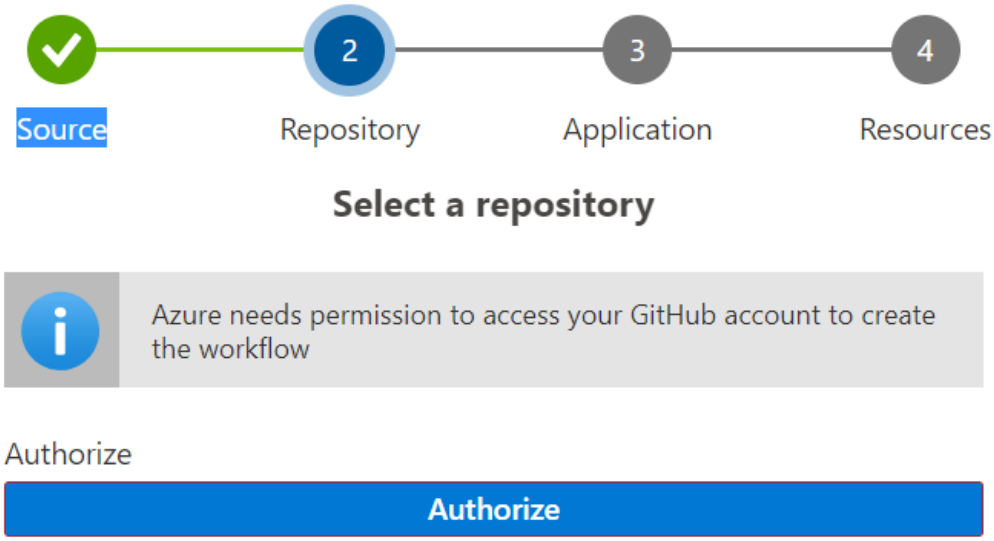


4. Continuous Deployment using DevOps pipelines (GitHub)

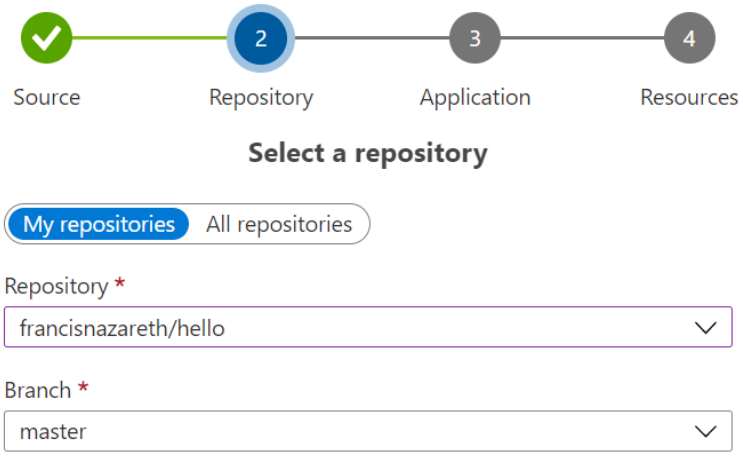
1. Signup / login to your GitHub account (www.github.com)
2. Fork the following repository -> francisnazareth/hello (github.com)
3. In the Azure Portal, search for the Kubernetes cluster you crated and go to the settings -> Deployment Center
4. Click on (+Add Projects)
5. In the source, select "GitHub" and click Next



6. In the repository screen, click on "Authorize" to authorize azure to access GitHub.

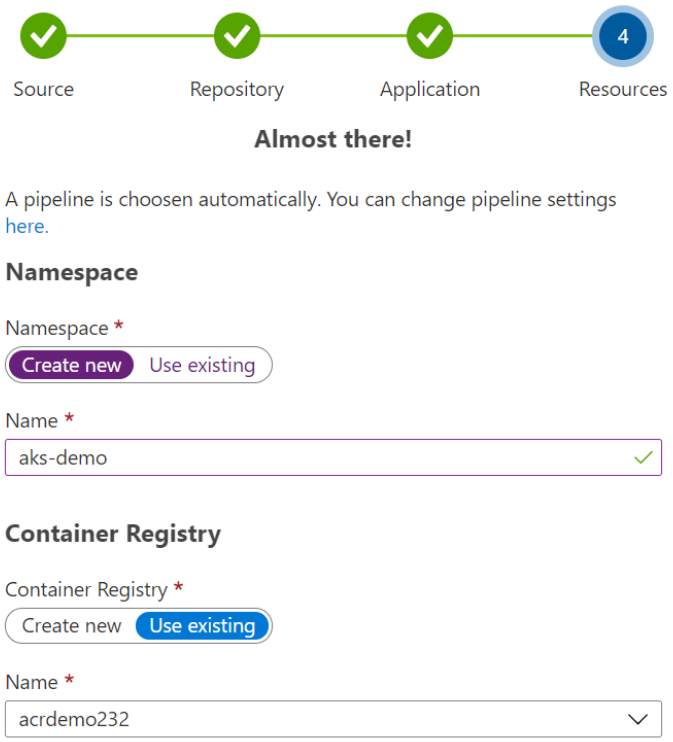


7. Once authorization is done, select the repository you forked

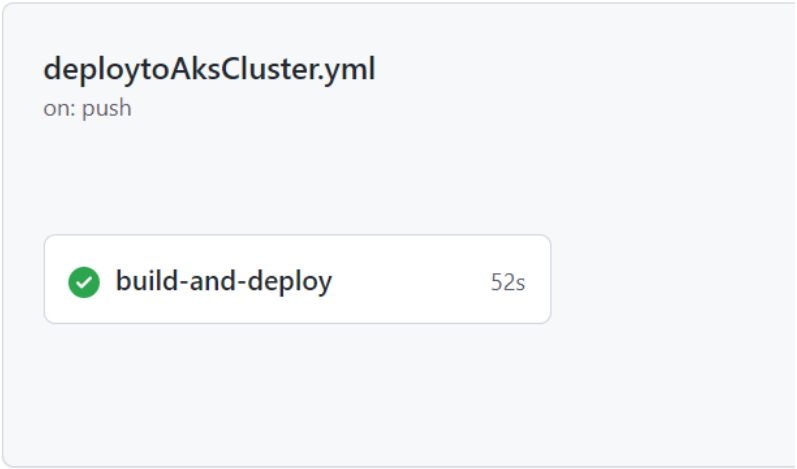


8. In the next screen, accept the defaults (deployment center automatically detects the Dockerfile).

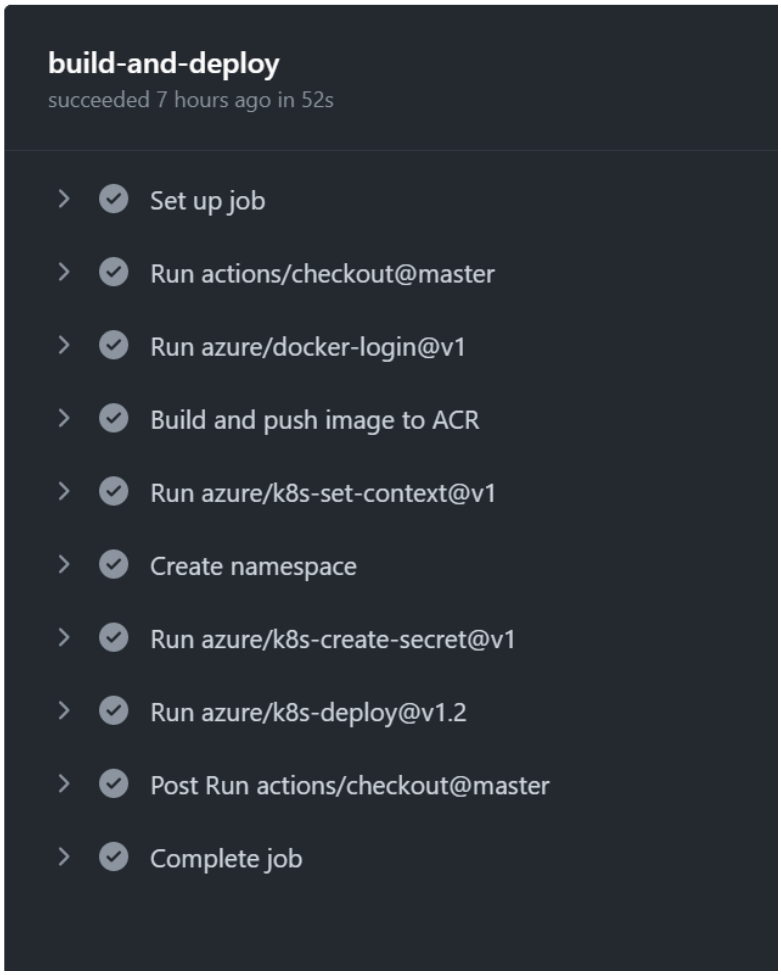
9. Accept the defaults for the namespace, select the Azure Container Registry that you created, and click “Done”.



10. In the project in deployment center, click on "View all runs"
11. This will take you to GitHub page. Click on the "Build & Deploy" GitHub action.



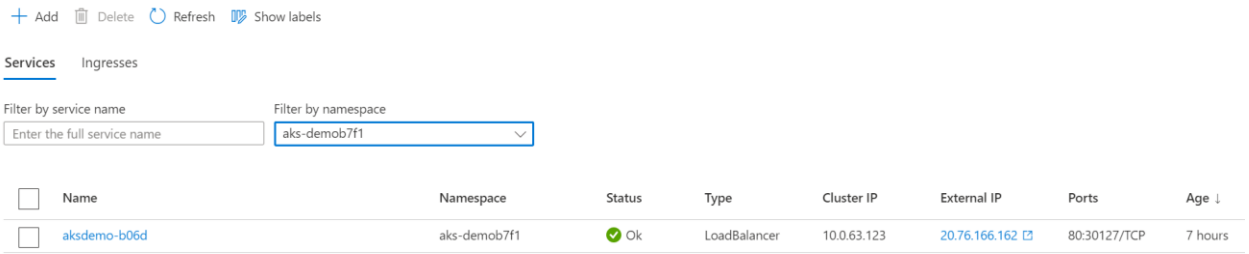
12. You should be able to view the pipeline steps that got executed.



13. In Azure Portal, within Deployment Center, view the manifest files deployment.yml and service.yml that got generated.

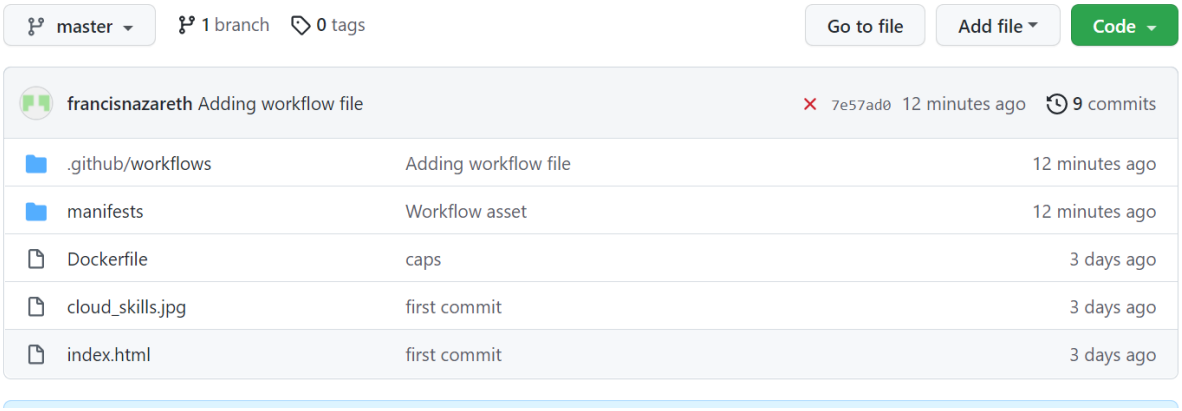
Also, make a note of the namespace that got generated.

14. In Azure Portal, within the cluster view, select "Kubernetes Resources -> Services and Ingresses". In Filter by namespace field select the namespace where deployment center created resources.

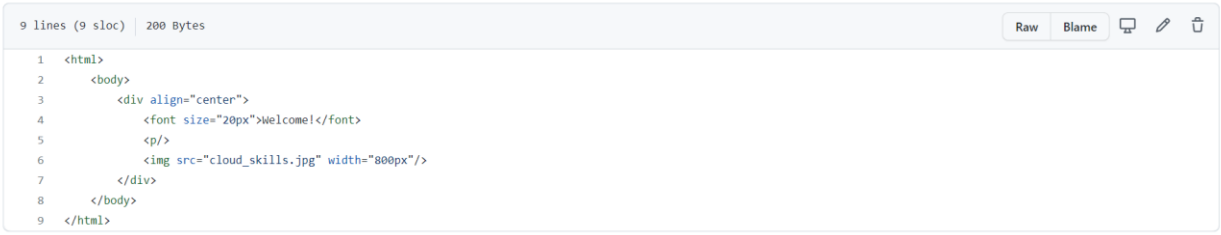


15. Click on the External IP to view the container application.

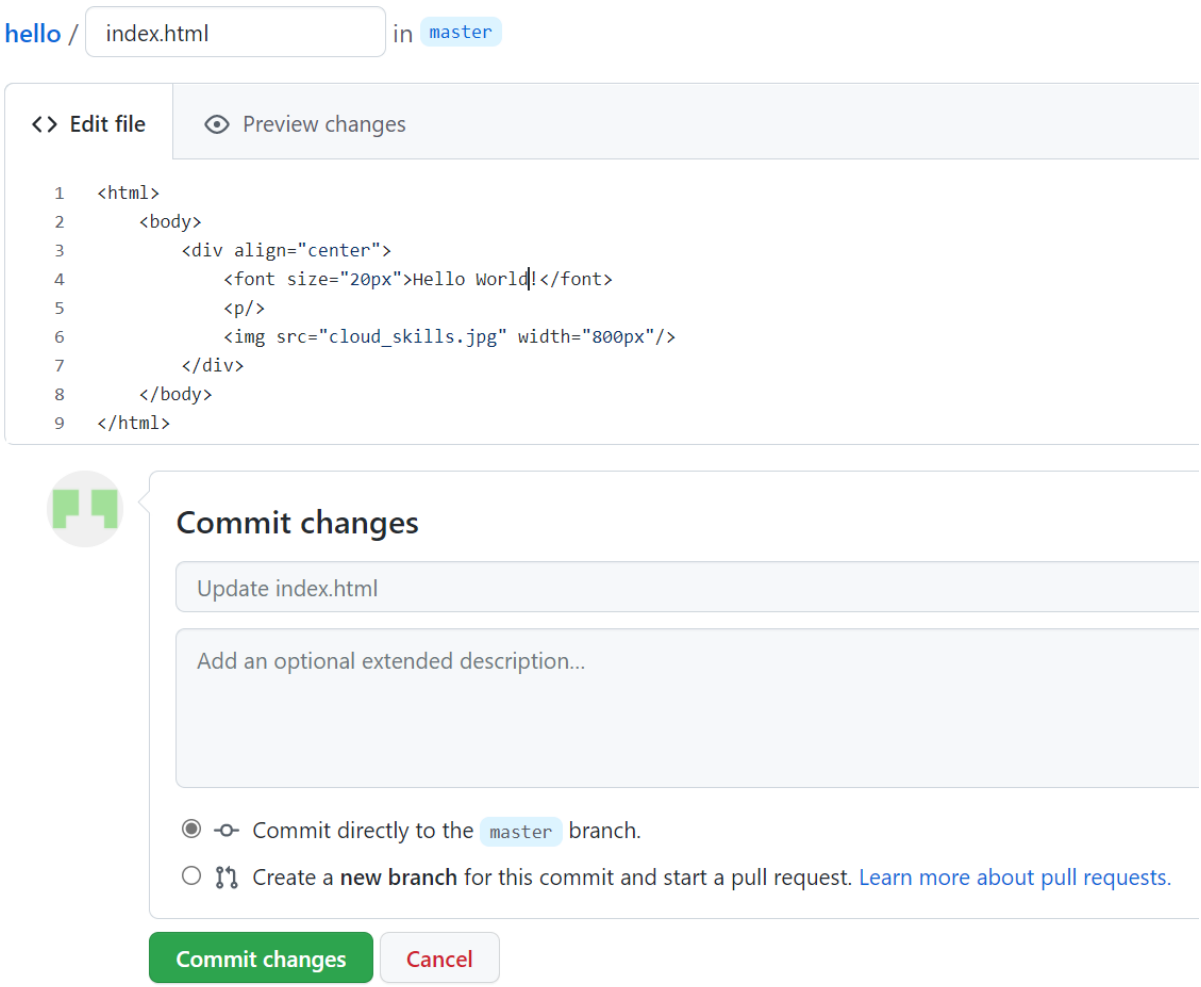
16. Go back to GitHub, go to “Code” tab, and select the file “index.html”



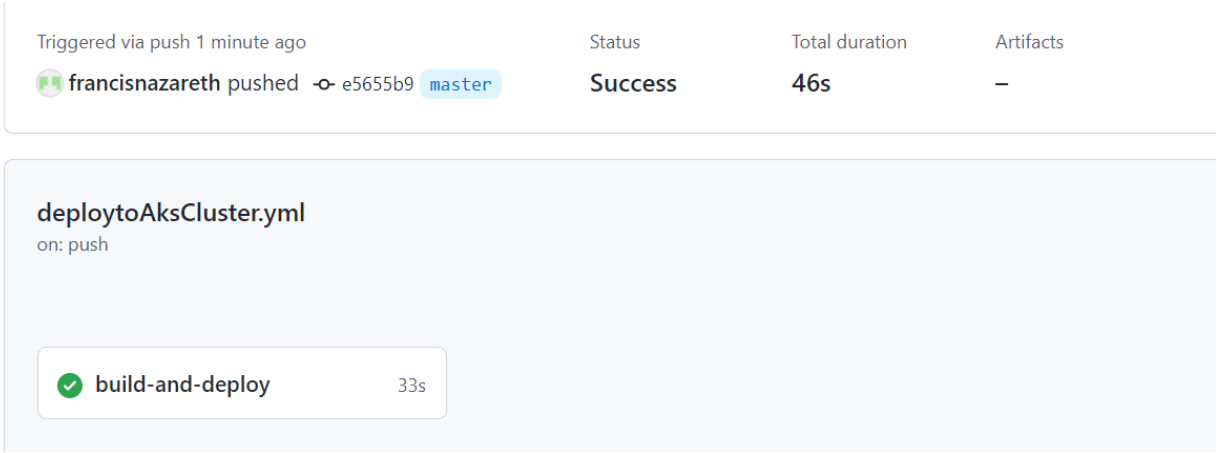
17. Edit the file (using the pencil icon)



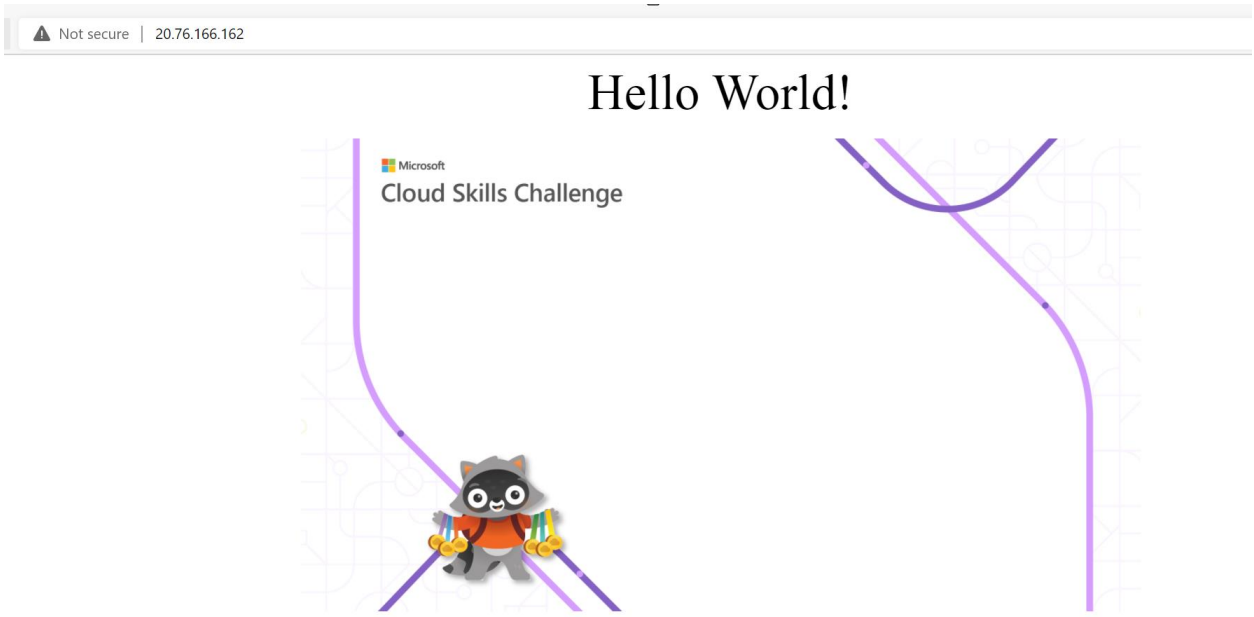
18. Edit the “Welcome!” text (in line 4) to something else, and click on “Commit Changes”.



19. Go to the Actions tab, and view the workflow executing.



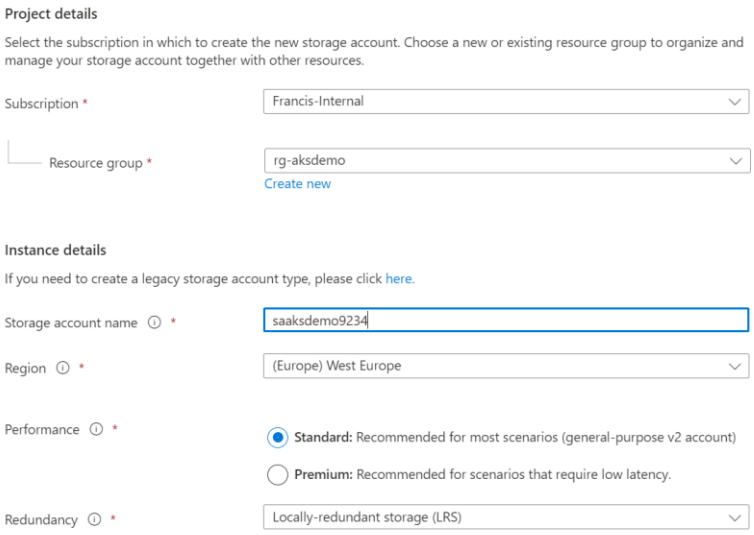
20. Refresh the web browser page with the Kubernetes service IP (from step 15). You should see the Kubernetes service referring to new container (built from the modified HTML file).



5. Mount Azure File Share as a Kubernetes volume

5.1 Create a storage account

1. Create an azure storage account (search for storage accounts), click on +Create.
2. Provide a unique name for the storage account.
3. Select the resource group, and select the same region as that of resource group.
4. Select the performance as standard
5. Select the redundancy as Locally Redundant Storage (LRS)



Click on "Review & Create", and Create.

5.2 Create a file share and upload an image to file share.

Once the storage account is provisioned, click on "Go to resource" to view properties of the storage account.

Create a file share within the storage account.

- In Data storage -> file shares, click (+FileShare) to create a file share.
- Provide a name (images) to the file share. And click Create.

New file share

Name *

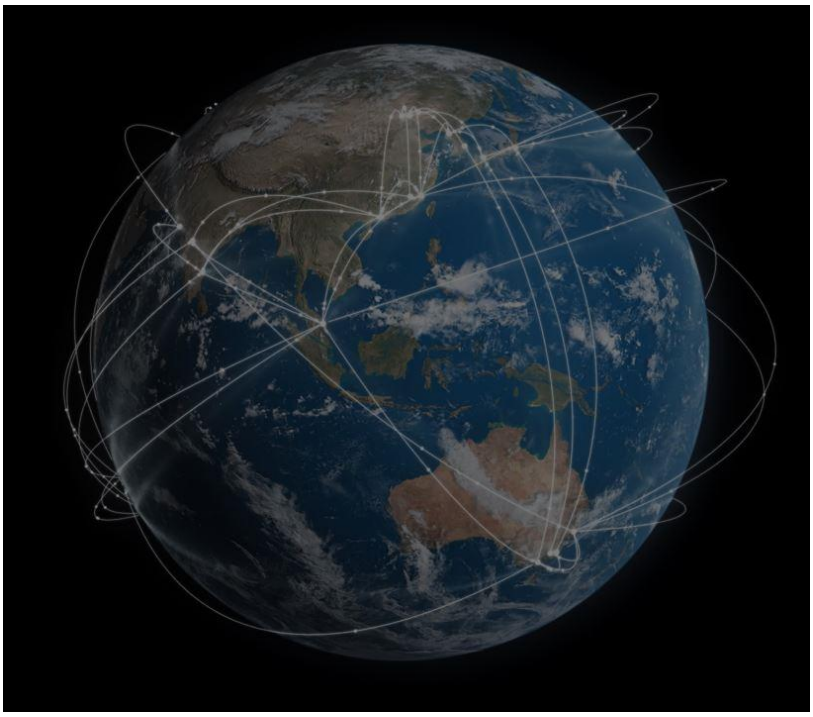
images

Tier ⓘ

Transaction optimized

Performance	
Maximum IO/s ⓘ	1000
Egress Rate ⓘ	60 MiBytes / s
Ingress Rate ⓘ	60 MiBytes / s
Maximum capacity	5 TiB
Large file shares	Disabled

Save the following picture as file "world.jpg" on your local machine (right click, save picture..).



- In Azure Portal, once the Azure file share is created, click on "Upload" to upload an image.
- Upload the image that you just saved to Azure File Share.

Copy the access key of storage account

- In the storage account, Go to "Security + Networking" -> Access Keys, and click on "Show Keys". Copy the value of key1.

Make a note of the following values:

1. Storage Account name
2. File Share name
3. Access Key of the storage account.

5.3 Create a Kubernetes secret.

In the cloud shell, create a Kubernetes secret using the following command:

kubectl create secret generic azure-file-secret --from-literal=azurestorageaccountname=<<storage account name>> --from-literal=azurestorageaccountkey=<<storage account key>>

For example,

kubectl create secret generic azure-file-secret --from-literal=azurestorageaccountname=saaksdemo9234 --from-literal=azurestorageaccountkey=NI7AJNUcL7Jwl59fMFYbMcR+fejoBIyjV2q0sgL8WLozjTDlyz2W9vifrmJti025pF3r7Ya3NubUuuFeg97FRA==

Note: Secret is a Kubernetes object that is used to store sensitive data. Secrets | Kubernetes

5.4 Create a new image and push to Azure Container Registry

Modify the HTML file (index.html) as follows:

```
<html>
  <body>
    <div align="center">
      <font size="20px">Welcome!</font>
      <p/>
```

```
        <img src="./images/world.jpg" width="600px"/>
      </div>
   </body>
</html>
```

Build a new image and push to the Azure Container Registry

az acr build --registry <<registry name>> --image <<image name>>:<<tag>>

For example,

az acr build --registry acrdemo232 --image nginx-mount:v1 .

5.6 Create a deployment that references Azure File Share (using the file share name and Kubernetes secret)

Create a deployment YAML file using the following command:

kubectl create deploy world-deploy --image <<registry URL>>/<<image>>:<<tag>> --replicas=3 --dry-run=client -o yaml > world-deploy.yaml

For example,

kubectl create deploy world-deploy --image acrdemo232.azurecr.io/nginx-mount:v1 --replicas=3 --dry-run=client -o yaml > world-deploy.yaml

Note: The --dry-run instructs the Kubernetes API server to not to create the objects. -o parameter specifies that the output should be in YAML format. We are redirecting the yaml format output to a file (using pipe (>))

Edit the file

code world-deploy.yaml

Add the sections volumeMounts and volumes as follows:

(Note: correct spaces – indentation – is important in YAML files).

```
apiVersion: apps/v1
kind: Deployment
metadata:
  creationTimestamp: null
  labels:
    app: world-deploy
  name: world-deploy
spec:
  replicas: 3
  selector:
    matchLabels:
      app: world-deploy
  strategy: {}
  template:
    metadata:
      creationTimestamp: null
      labels:
        app: world-deploy
    spec:
      containers:
      - image: acrdemo232.azurecr.io/nginx-mount:v1
        name: mynginx
        resources: {}
        volumeMounts:
        - name: my-images
          mountPath: /usr/share/nginx/html/images
      volumes:
      - name: my-images
```

```
      azureFile:
        secretName: azure-file-secret
        shareName: images
        readOnly: false
status: {}
```

Save & Quit (CTRL + S, followed by CTRL + Q)

Apply the YAML file

kubectl apply -f world-deploy.yaml

5.6 Expose the deployment as a service.

a. Expose the deployment as a Kubernetes service:

kubectl expose deploy world-deploy --port=80 --type=LoadBalancer

b. View the public IP address for the service:

kubectl get svc

c. Access the IP address in a browser, you should be able to see the web site with image loaded from Azure Storage account.

Note: We mounted the azure file share to container in the path /usr/share/nginx/html/images. Hence an HTML file in the path /usr/share/nginx/html/ is able to access the image as /images/world.jpg.

Please note that we are referring to the storage account and file share in the YAML using the secret name (which contains the storage account name and storage account key) and the file share name, in the volumes section of the YAML. The volume name has to match with the volume mount name. We specify the mount path in the volume mount section.

6: Create an ingress controller and routes

Note that each of our services had a public IP address. This is not ideal – we should ideally have only one access IP address for the Kubernetes cluster, and should have multiple deployments routes through this common IP address. For example, <ip address>/hello should go to our first deployment, and <ip address>/world should go to our second deployment.

Let us create an (NGINX) ingress controller and route the traffic through the ingress controller.

6.1 Install the nginx ingress controller using helm

```
helm repo add ingress-nginx https://kubernetes.github.io/ingress-nginx

helm repo update

kubectl create namespace ingress-nginx

helm install ingress-one ingress-nginx/ingress-nginx --set
controller.ingressClass="ingress-one" --namespace ingress-nginx --version 3.39.0
```

6.2 Delete the existing services

kubectl delete service hello-deploy

kubectl delete service world-deploy

6.3 Recreate the services again, this time with ClusterIP as the type.

```
kubectl expose deploy hello-deploy --port=80 --target-port=80 --type=ClusterIP

kubectl expose deploy world-deploy --port=80 --target-port=80 --type=ClusterIP
```

Note: The services that we created earlier were of type LoadBalancer, and hence the service got a public IP address. Now, we are creating the service to be of type ClusterIP, which doesn't provide a public IP address. Services of the type ClusterIP can be accessed by objects within the Kubernetes cluster but not from outside.

6.4 Check the IP addresses of the services

kubectl get services

(You will see that the services do not have a public IP anymore).

6.5 Create an ingress resource using the following file (copy the contents to a file hello-world-ingress.yaml)

code hello-world-ingress.yaml

```yaml
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: hello-world-ingress
  annotations:
    kubernetes.io/ingress.class: ingress-one
    nginx.ingress.kubernetes.io/ssl-redirect: "false"
    nginx.ingress.kubernetes.io/use-regex: "true"
    nginx.ingress.kubernetes.io/rewrite-target: /$1
spec:
  rules:
  - http:
      paths:
      - path: /world(/|$)(.*)
        pathType: Prefix
        backend:
          service:
            name: world-deploy
            port:
              number: 80
      - path: /hello(/|$)(.*)
        pathType: Prefix
        backend:
          service:
            name: hello-deploy
            port:
              number: 80
      - path: /(.*)
        pathType: Prefix
        backend:
          service:
            name: world-deploy
            port:
              number: 80
---
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: hello-world-ingress-static
```

```
  annotations:
    kubernetes.io/ingress.class: ingress-one
    nginx.ingress.kubernetes.io/ssl-redirect: "false"
    nginx.ingress.kubernetes.io/rewrite-target: /static/$2
spec:
  rules:
  - http:
      paths:
      - path:
        pathType: Prefix
        backend:
          service:
            name: world-deploy
            port:
              number: 80
        path: /static(/|$)(.*)
```

Create the ingress resource:

kubectl apply -f hello-world-ingress.yaml

6.6 Get the external IP address of ingress

kubectl --namespace ingress-nginx get services

6.7 Try to access the website with following URLs

http://<ingress external IP>/

(this goes to the default path / in our ingress routing rules)

http://<ingress external IP>/hello

(this goes to the path /hello in our ingress routing rules)

http://<ingress external IP>/world

(this goes to the path /world in our ingress routing rules)

7: Publish utility microservices

Four utility microservices are provided in the following Github location:

Microservice	URL
Water and Electricity Usage Microservice	microservices/WaterAndElectricityUsage at main · francisnazareth/microservices (github.com)
Mobile and Internet Bill Microservice	microservices/MobileAndInternetBill at main · francisnazareth/microservices (github.com)
Loyalty Points Microservice	microservices/LoyaltyPoints at main · francisnazareth/microservices (github.com)
Health Statistics Microservice	microservices/HealthStats at main · francisnazareth/microservices (github.com)

If you browse through the repositories you will see that each of the repository has a Dockerfile and dotnet source code.

Let us build and deploy these microservices

1. Clone the source code to your cloud shell environment

git clone https://github.com/francisnazareth/microservices.git

2. Build the container images, and push the images to Azure Container Registry

From Azure Cloud Shell, issue the following commands (replace <<your registry name>> with the name of container registry that you created:

RegistryName= <<your registry name>>
az acr build --registry $RegistryName --image electricitybill:v1 ./microservices/WaterAndElectricityUsage

az acr build --registry $RegistryName --image mobilebill:v1 ./microservices/MobileAndInternetBill

az acr build --registry $RegistryName --image loyaltypoints:v1 ./microservices/LoyaltyPoints

az acr build --registry $RegistryName --image healthstats:v1 ./microservices/HealthStats

3. Create an ingress controller for Microservices

```
helm install ingress-microsvc ingress-nginx/ingress-nginx --set
controller.ingressClass="microsvc" --namespace ingress-nginx --version 3.39.0
```

4. Create the microservice deployments, services, and ingress routes using a YAML file.

a) Edit the file microsvc.yml

code microservices/microsvc.yml

b) Replace the word YOUR_REGISTRY with the name of your container registry (CTRL + H). Note that there are four occurrences.
c) Save the file (CTRL + S) and quit the editor (CTRL + Q)
d) Create the Kubernetes artifacts using the command

kubectl apply -f microservices/microsvc.yml

5. Get the ingress IP address
   kubectl get ingress -n microservices

6. Try invoking microservices in a browser:

a) Mobile & Internet Bill microservice
   - Service URL: http://<<ingress IP>>/mobilebill/api/MobileBill/88888888
   - OpenAPI definition: http://<<ingress IP>>/mobilebill/swagger/v1/swagger.json

b) Water & Electricity Bill microservice
   - Service URL: http://<<ingress IP>>/electricitybill/api/UtilityBill/1234
   - Open API definition: http://<<ingress IP>>/electricitybill/swagger/v1/swagger.json

c) Loyalty Points microservice
   - Service URL: http://<<ingress IP>>/loyalty/api/Loyalty/1234
   - Open API definition: http://<<ingress IP>>/loyalty/swagger/v1/swagger.json

d) Health Statistics
   - Service URL: http://<<ingress IP>>/healthstats/api/HealthStats/1234
   - Open API definition: http://<<ingress IP>>/healthstats/swagger/v1/swagger.json

We may use the microservices you deployed now in API management lab & app service lab.

- End of Lab