VMware Advanced Customer Engagements (ACE) Team

Tanzu Kubernetes Grid Workload Isolation using NSX-T Micro Segmentation

Authored by Riaz Mohamed & Raghu Pemmaraju

May 2020

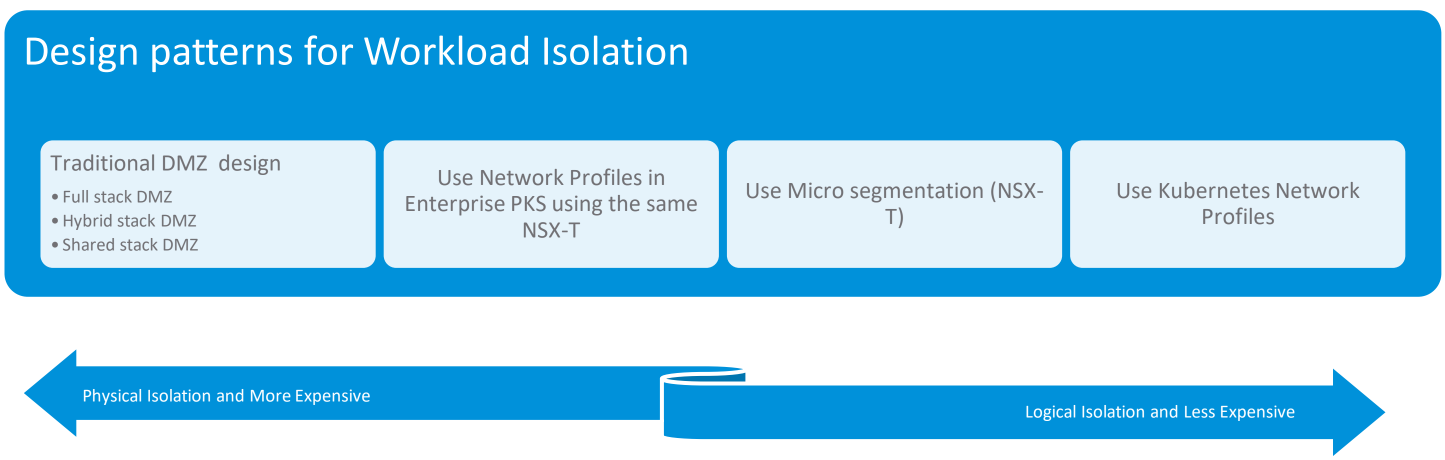
Table of Contents

Introduction

Containers provide a great deal of benefits to your development pipeline and support resource isolation but they're not designed with strong network security boundaries or workload isolation. By default, pods are non-isolated; they accept traffic from any source.

Tanzu Kubernetes Grid Integrated (TKGI previously knowns as Enterprise PKS) coupled with VMware NSX-T Data Center (NSX-T), and VMware vSphere provides an agile, software defined platform to deliver cloud-native applications. NSX-T primarily focuses on networking and security for these applications and the features support implementing stronger workload isolation.

In TKGI, workload isolation can be performed by physically isolating workload at the vSphere cluster (group of physical hosts) level or by logically isolating workloads within the TKGI deployed clusters (at cluster or namespace isolation). The following design patterns can be considered for workload isolation.

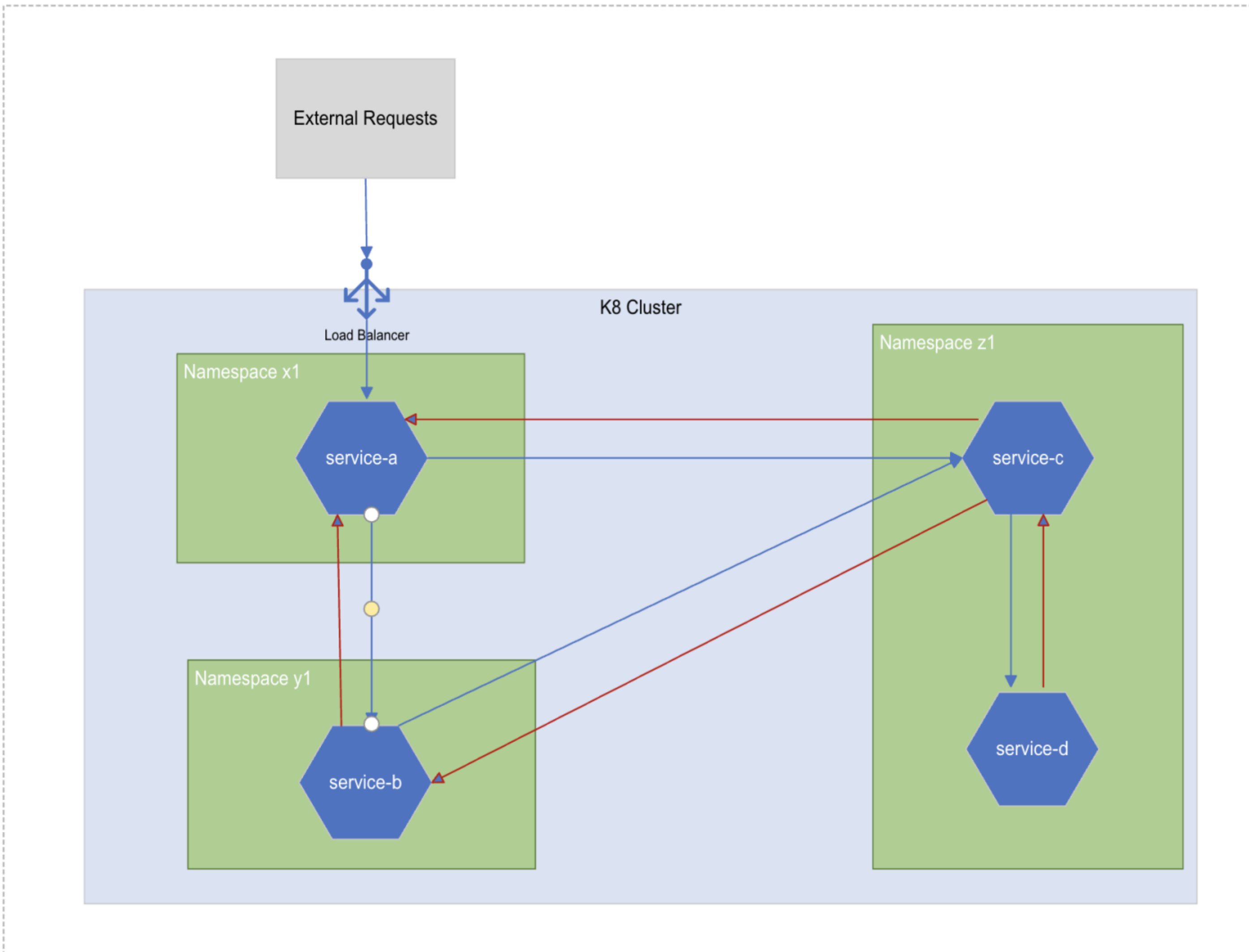


In this document, we focus on how to leverage the micro-segmentation feature within NSX-T to provide workload isolation. NSX-T comes with a distributed firewall that can provide complete control of both North-South Traffic but also East-West Traffic and can isolate workloads, even if they are next to each other. For example, traditional firewalls only isolate network traffic between network VLANs or segments but not within a network segment. But with NSX-T distributed firewall, you can create rules to isolate workload on the same segment and with Kubernetes tags, you can isolate even Kubernetes pod-to-pod communication.

In this document, we take a simple application that has several components or services. These services are required to communicate with each other in a very defined manner. For example, service-a needs to communicate with service-c and service-b but not with any other service. Similarly, service-c needs to communicate with service-d but not with service-a or service-b.

In such a scenario, we look at how to isolate the workload using NSX-T, and also show how this is done dynamically as pods are created and destroyed.

For this guide, consider the following application with few loosely coupled services. Assume that all ingress traffic from outside the cluster comes into service-a. service-a is running in namespace x1 and typically will use ingress controller like Nginx or Contour. service-a routes to service-b or service-c, and service-c might need to talk to service-d. This diagram shows which workload is allowed and not allowed between the services.



Use-case

The k8s cluster has three namespaces (namespace x1, y1 and z1). All ingress into the cluster must be restricted to namespace x1 and pod service-a.
Namespace y1 runs a pod service-b and namespace z1 runs pods service-c and service-d.

Traffic flows

All ingress traffic into the cluster can only be serviced by service-a on namespace x1 which means the following traffic flow rules must be enforced:

Service-b allows traffic from service-a
Service-b denies traffic from service-c
Service-c allows traffic from service-a and service-b
Service-d allows traffic from only service-c
Service-c denies traffic from service-d

Assumptions

K8s cluster managed by TKGI (PKS) exists with NSX-T as the networking layer

K8s Resources

In this section, the K8S resources associated with the sample application and services is described.

Pod Definition

The sample application will have a pod definition with 2 containers:

- nginx (to service web requests)
- busybox with curl (container to test service-to-service traffic)

Deployments and Services

service-a, service-b, service-c and service-d are identical and run the above pod definition on their respective namespaces. They run two replicas and are exposed as services svc-service-a, svc-service-b, svc-service-c, and svc-service-d.

K8s Resource Deployments

This section goes through the steps to set up the K8 environment with the deployments in their respective namespaces. At the end of the setup, a test will be performed to verify that the traffic flows between the services.

K8 Deployments

1. **Login to k8s cluster**

    pks login -a <pks-api> -u <pksuser> -p <pks-password> -k

    e.g.
    pks login -a pks.corp.local -u pksadmin -p VMware1! -k

2. **Get Kubeconfig**

    pks get-kubeconfig <cluster-name> -a <pks-api> -u <pksuser> -p <pks-password> -k

    e.g.

    pks get-kubeconfig ci-cluster -a pks.corp.local -u pksadmin -p VMware1! -k

3. **Change context**

    kubectl config use-context ci-cluster

4. **Create Namespace x1, y1, z1**

    kubectl create ns x1

    kubectl create ns y1

    kubectl create ns z1

```
ubuntu@cli-vm:~/dmz$ kubectl create ns x1
namespace/x1 created
ubuntu@cli-vm:~/dmz$
ubuntu@cli-vm:~/dmz$ kubectl create ns y1
namespace/y1 created
ubuntu@cli-vm:~/dmz$
ubuntu@cli-vm:~/dmz$ kubectl create ns z1
namespace/z1 created
```

5. **Check if namespace is created**

kubectl ge ns

```
ubuntu@cli-vm:~/dmz$ kubectl get ns
NAME              STATUS   AGE
default           Active   12d
jenkinso          Active   11d
kube-node-lease   Active   12d
kube-public       Active   12d
kube-system       Active   12d
pks-system        Active   11d
x1                Active   13s
y1                Active   13s
z1                Active   13s
```

6. **Create Deployments & Services**

Download the yaml file or copy contents to a local file e.g. micro.yaml. This file declares the K8 resources required. Create the necessary resources in their respective namespaces

https://github.com/riazvm/nsxtk8smicrosegmentation/blob/master/yaml/micro.yaml

kubectl apply -f micro.yaml

```
ubuntu@cli-vm:~/dmz$ vi micro.yaml
ubuntu@cli-vm:~/dmz$ kubectl apply -f micro.yaml
deployment.apps/service-a created
service/svc-service-a created
deployment.apps/service-b created
service/svc-service-b created
deployment.apps/service-c created
service/svc-service-c created
deployment.apps/service-d created
service/svc-service-d created
ubuntu@cli-vm:~/dmz$
```

7. Check services and pods created in each namespace

kubectl get all -n x1

```
ubuntu@cli-vm:~/dmz$ kubectl get all -n x1
NAME                                READY   STATUS    RESTARTS   AGE
pod/service-a-84965f57cc-nhbrx      2/2     Running   0          105s
pod/service-a-84965f57cc-q72fh      2/2     Running   0          105s

NAME                     TYPE        CLUSTER-IP       EXTERNAL-IP   PORT(S)   AGE
service/svc-service-a    ClusterIP   10.100.200.143   <none>        80/TCP    105s

NAME                         READY   UP-TO-DATE   AVAILABLE   AGE
deployment.apps/service-a    2/2     2            2           105s

NAME                                     DESIRED   CURRENT   READY   AGE
replicaset.apps/service-a-84965f57cc     2         2         2       105s
```

kubectl get all -n y1

```
ubuntu@cli-vm:~/dmz$ kubectl get all -n y1
NAME                                READY   STATUS    RESTARTS   AGE
pod/service-b-86d8c888c7-6r9kp      2/2     Running   0          2m39s
pod/service-b-86d8c888c7-jpwf9      2/2     Running   0          2m39s

NAME                     TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)   AGE
service/svc-service-b    ClusterIP   10.100.200.12   <none>        80/TCP    2m39s

NAME                         READY   UP-TO-DATE   AVAILABLE   AGE
deployment.apps/service-b    2/2     2            2           2m39s

NAME                                     DESIRED   CURRENT   READY   AGE
replicaset.apps/service-b-86d8c888c7     2         2         2       2m39s
```

kubectl get all -n z1

```
ubuntu@cli-vm:~/dmz$ kubectl get all -n z1
NAME                                 READY   STATUS    RESTARTS   AGE
pod/service-c-5c5fc5c857-d9sqm       2/2     Running   0          2m52s
pod/service-c-5c5fc5c857-jxqbh       2/2     Running   0          2m52s
pod/service-d-69f59f4cb9-f94rs       2/2     Running   0          2m52s
pod/service-d-69f59f4cb9-pkplt       2/2     Running   0          2m52s

NAME                     TYPE        CLUSTER-IP       EXTERNAL-IP   PORT(S)   AGE
service/svc-service-c    ClusterIP   10.100.200.117   <none>        80/TCP    2m52s
service/svc-service-d    ClusterIP   10.100.200.211   <none>        80/TCP    2m52s

NAME                          READY   UP-TO-DATE   AVAILABLE   AGE
deployment.apps/service-c     2/2     2            2           2m52s
deployment.apps/service-d     2/2     2            2           2m52s

NAME                                     DESIRED   CURRENT   READY   AGE
replicaset.apps/service-c-5c5fc5c857     2         2         2       2m52s
replicaset.apps/service-d-69f59f4cb9     2         2         2       2m52s
```

8. Expose service-a as a load-balancer service

kubectl expose deployment service-a \
--name=service-a-lb --port=80 --target-port=8080 --type=LoadBalancer --namespace=x1

```
ubuntu@cli-vm:~/dmz$ kubectl expose deployment service-a \
> --name=service-a-lb --port=80 --target-port=8080 --type=LoadBalancer --namespace=x1
service/service-a-lb exposed
```

9. Check the external URL/IP address assigned to the service (make note of the first IP addres under External-IP).

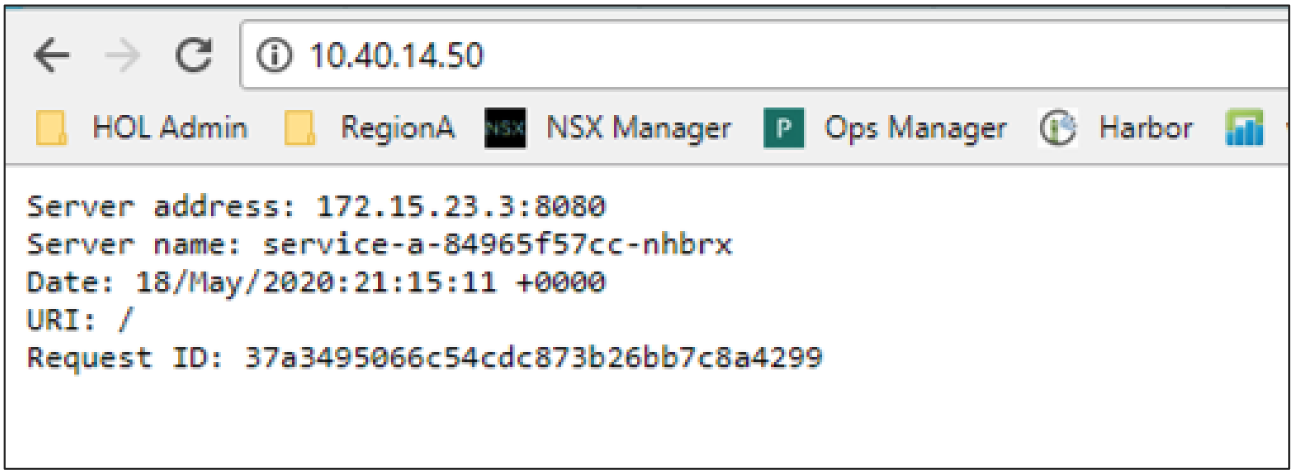
kubectl get svc -n x1

```
ubuntu@cli-vm:~/dmz$ kubectl get svc -n x1
NAME            TYPE           CLUSTER-IP       EXTERNAL-IP    PORT(S)        AGE
service-a-lb    LoadBalancer   10.100.200.49    10.40.14.50    80:32650/TCP   12s
svc-service-a   ClusterIP      10.100.200.143   <none>         80/TCP         15m
```

Current Traffic Flow

Traffic flow from external network to k8 cluster.

Open a browser and browse to the external ip from the previous step



service-a can be reached from the external network through the load balancer which is created in NSX-T

service-b, service-c and service-d are not exposed and hence are not reachable from the external network.

Traffic flow between pods

We will be using the busy-box container within service-a pod and use curl to check for responses between service.

Source Service – service-a (namespace x1)
Target Service – service-b (namespace y1)

1. Get pods running on namespace x1

   kubectl get po -n x1

```
ubuntu@cli-vm:~/dmz$ kubectl get po -n x1
NAME                          READY   STATUS    RESTARTS   AGE
service-a-84965f57cc-nhbrx    2/2     Running   0          31m
service-a-84965f57cc-q72fh    2/2     Running   0          31m
ubuntu@cli-vm:~/dmz$
```

2. Get service name for service-b running on namespace y1

   kubectl get svc -n y1

```
ubuntu@cli-vm:~/dmz$ kubectl get svc -n y1
NAME            TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)   AGE
svc-service-b   ClusterIP   10.100.200.12   <none>        80/TCP    38m
```

3. Exec into the busybox container running on a service-a pod

   kubectl exec -n <namespace> <podname> -it -c busybox -- /bin/sh
   Eg

   kubectl exec -n x1 service-a-84965f57cc-nhbrx -it -c busybox -- /bin/sh

```
ubuntu@cli-vm:~/dmz$  kubectl exec -n x1 service-a-84965f57cc-nhbrx -it -c busybox -- /bin/sh
/home #
/home #
```

4. Use curl to reach service-b in namespace y1

   curl *http://svc-service-b.y1*

   NOTE: the service name is prepended by svc in this case, this is defined in the yaml we used to create the K8 resources. The service name is also appended by the namespace.

5. This results in a successful response

```
ubuntu@cli-vm:~/dmz$ kubectl exec -n x1 service-a-84965f57cc-nhbrx -it -c busybox -- /bin/sh
/home # curl http://svc-service-b.y1
Server address: 172.15.13.3:8080
Server name: service-b-86d8c888c7-jpwf9
Date: 18/May/2020:21:38:00 +0000
URI: /
Request ID: cfe8d330cac2894b204a1b57082e10cc
```

6. Use the curl command to check the service response of service-d in namespace z1

curl *http://svc-service-d.z1*

This should be successful as well

```
ubuntu@cli-vm:~/dmz$ kubectl exec -n x1 service-a-84965f57cc-nhbrx -it -c busybox -- /bin/sh
/home # curl http://svc-service-b.y1
Server address: 172.15.13.3:8080
Server name: service-b-86d8c888c7-jpwf9
Date: 18/May/2020:21:38:00 +0000
URI: /
Request ID: cfe8d330cac2894b204a1b57082e10cc
/home # curl http://svc-service-d.z1
Server address: 172.15.9.4:8080
Server name: service-d-69f59f4cb9-f94rs
Date: 18/May/2020:21:40:51 +0000
URI: /
Request ID: 9acb24c07338cadfa53b59c99f042c47
```

At this point all services should be able to communicate to each other. The only traffic allowed from outside the cluster is to service-a via the loadbalancer.

Configure Micro Segmentation with NSX-T

This section goes through the configuration of NSX-T DFW rules that are required to allow, restrict or drop pod to pod traffic.

1. Check labels on the pods

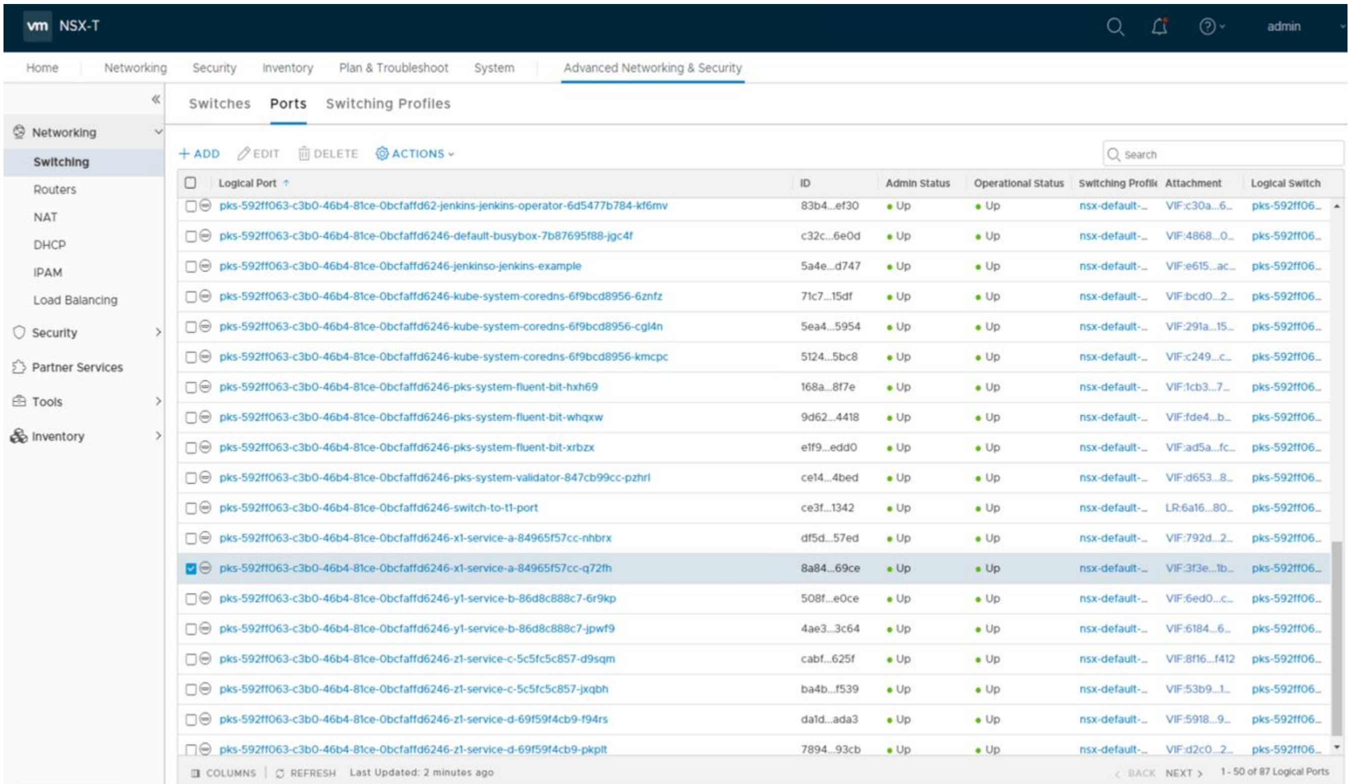
kubectl get pod --show-labels -n x1

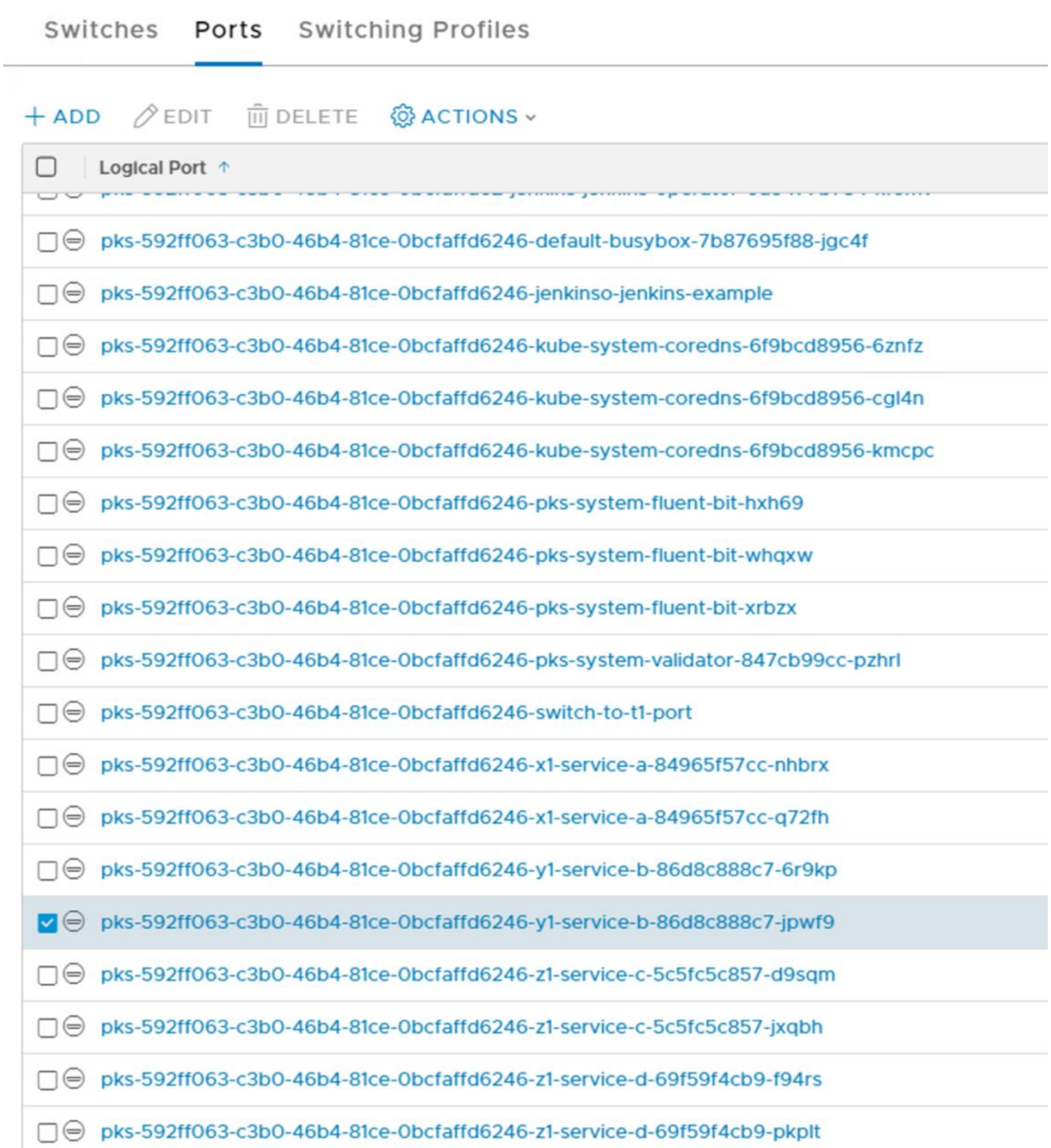
Check the labels on the pods in namespace y1 and z1 as well. All tags are defined as app={service name}. e.g.: app=service-a

```
ubuntu@cli-vm:~/dmz$ kubectl get pod --show-labels -n x1
NAME                          READY   STATUS    RESTARTS   AGE   LABELS
service-a-84965f57cc-nhbrx    2/2     Running   0          80m   app=service-a,pod-template-hash=84965f57cc
service-a-84965f57cc-q72fh    2/2     Running   0          80m   app=service-a,pod-template-hash=84965f57cc
ubuntu@cli-vm:~/dmz$ kubectl get pod --show-labels -n yi
No resources found.
ubuntu@cli-vm:~/dmz$ kubectl get pod --show-labels -n y1
NAME                          READY   STATUS    RESTARTS   AGE   LABELS
service-b-86d8c888c7-6r9kp    2/2     Running   0          81m   app=service-b,pod-template-hash=86d8c888c7
service-b-86d8c888c7-jpwf9    2/2     Running   0          81m   app=service-b,pod-template-hash=86d8c888c7
ubuntu@cli-vm:~/dmz$ kubectl get pod --show-labels -n z1
NAME                          READY   STATUS    RESTARTS   AGE   LABELS
service-c-5c5fc5c857-d9sqm    2/2     Running   0          81m   app=service-c,pod-template-hash=5c5fc5c857
service-c-5c5fc5c857-jxqbh    2/2     Running   0          81m   app=service-c,pod-template-hash=5c5fc5c857
service-d-69f59f4cb9-f94rs    2/2     Running   0          81m   app=service-d,pod-template-hash=69f59f4cb9
service-d-69f59f4cb9-pkplt    2/2     Running   0          81m   app=service-d,pod-template-hash=69f59f4cb9
```

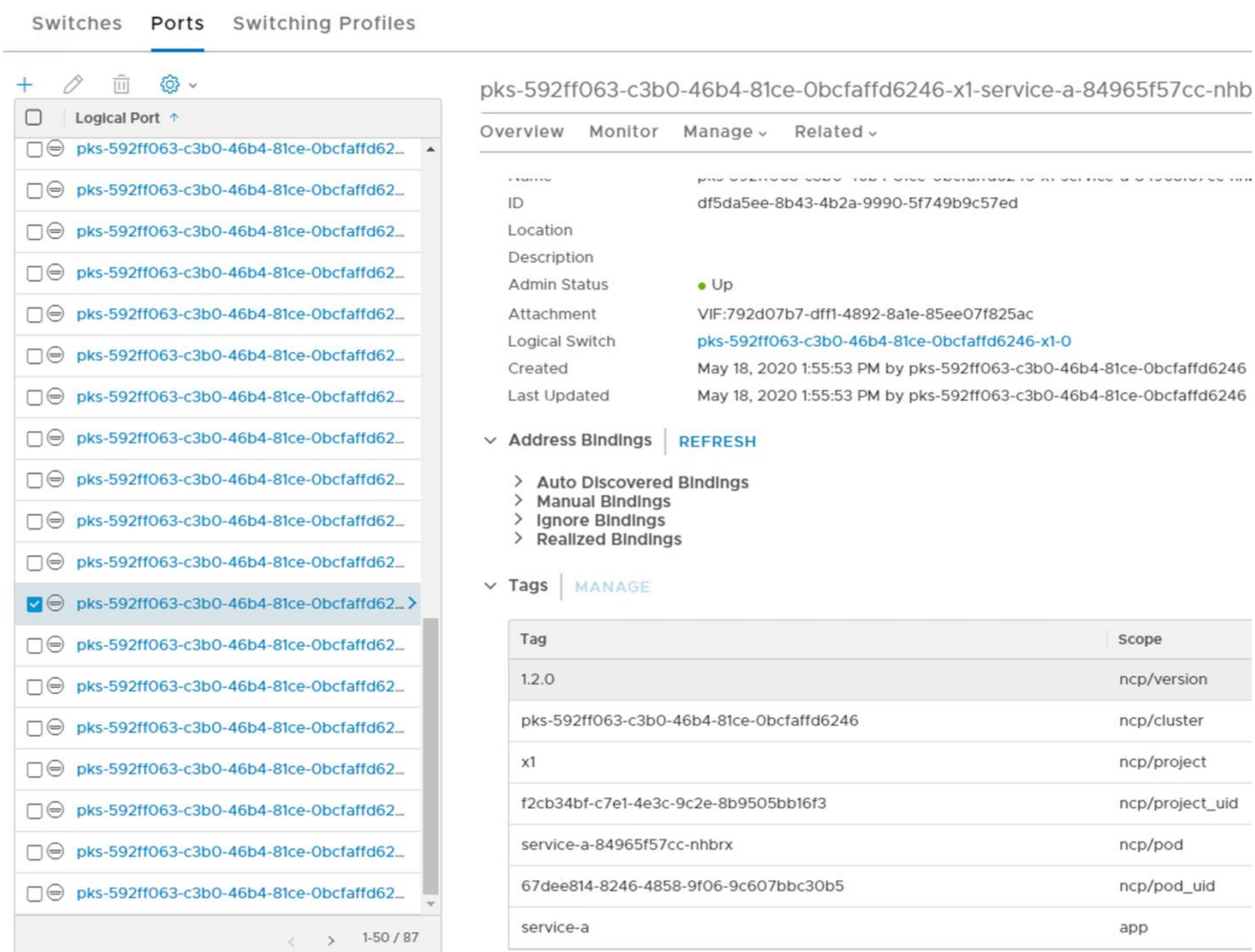
2. Check tags for pods in NSX-T

Login to NSX-T Manager and navigate to Advanced Networking & Security > Switching > Ports
The pods service-a, service-b, service-c and service-d would have a logical port assigned to them.


NSX-T
admin
Home
Networking
Security
Inventory
Plan & Troubleshoot
System
Advanced Networking & Security
Networking
Switching
Routers
NAT
DHCP
IPAM
Load Balancing
Security
Partner Services
Tools
Inventory
Switches
Ports
Switching Profiles
+ ADD
EDIT
DELETE
ACTIONS
Search
Logical Port
ID
Admin Status
Operational Status
Switching Profile
Attachment
Logical Switch
pks-592ff063-c3b0-46b4-81ce-0bcfaffd62-jenkins-jenkins-operator-6d5477b784-kf6mv
pks-592ff063-c3b0-46b4-81ce-0bcfaffd6246-default-busybox-7b87695f88-jgc4f
pks-592ff063-c3b0-46b4-81ce-0bcfaffd6246-jenkinso-jenkins-example
pks-592ff063-c3b0-46b4-81ce-0bcfaffd6246-kube-system-coredns-6f9bcd8956-6znfz
pks-592ff063-c3b0-46b4-81ce-0bcfaffd6246-kube-system-coredns-6f9bcd8956-cgl4n
pks-592ff063-c3b0-46b4-81ce-0bcfaffd6246-kube-system-coredns-6f9bcd8956-kmcpc
pks-592ff063-c3b0-46b4-81ce-0bcfaffd6246-pks-system-fluent-bit-hxh69
pks-592ff063-c3b0-46b4-81ce-0bcfaffd6246-pks-system-fluent-bit-whqxw
pks-592ff063-c3b0-46b4-81ce-0bcfaffd6246-pks-system-fluent-bit-xrbzx
pks-592ff063-c3b0-46b4-81ce-0bcfaffd6246-pks-system-validator-847cb99cc-pzhrl
pks-592ff063-c3b0-46b4-81ce-0bcfaffd6246-switch-to-t1-port
pks-592ff063-c3b0-46b4-81ce-0bcfaffd6246-x1-service-a-84965f57cc-nhbrx
pks-592ff063-c3b0-46b4-81ce-0bcfaffd6246-x1-service-a-84965f57cc-q72fh
pks-592ff063-c3b0-46b4-81ce-0bcfaffd6246-y1-service-b-86d8c888c7-6r9kp
pks-592ff063-c3b0-46b4-81ce-0bcfaffd6246-y1-service-b-86d8c888c7-jpwf9
pks-592ff063-c3b0-46b4-81ce-0bcfaffd6246-z1-service-c-5c5fc5c857-d9sqm
pks-592ff063-c3b0-46b4-81ce-0bcfaffd6246-z1-service-c-5c5fc5c857-jxqbh
pks-592ff063-c3b0-46b4-81ce-0bcfaffd6246-z1-service-d-69f59f4cb9-f94rs
pks-592ff063-c3b0-46b4-81ce-0bcfaffd6246-z1-service-d-69f59f4cb9-pkplt
COLUMNS
REFRESH
Last Updated: 2 minutes ago
BACK
NEXT
1 - 50 of 87 Logical Ports

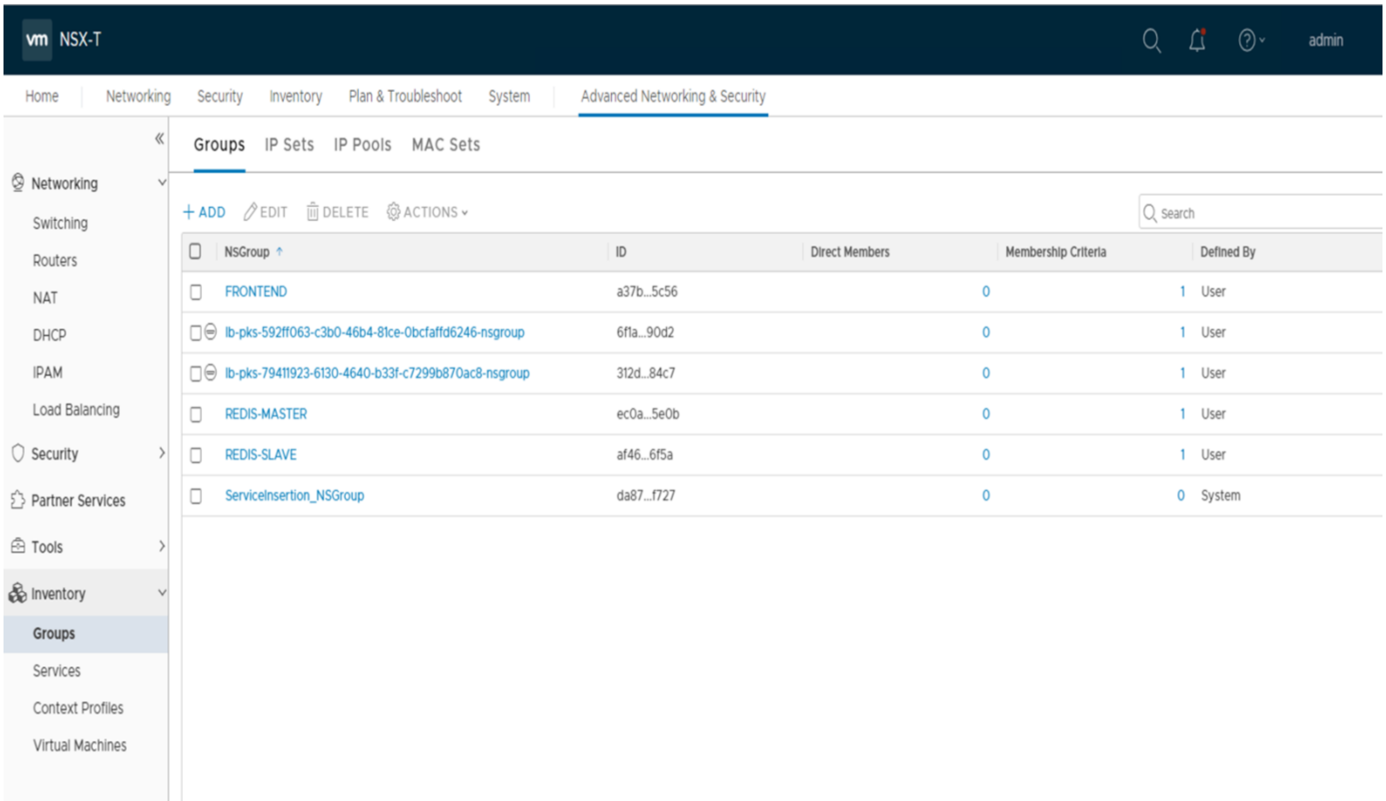


From the Logica Ports list, click on one of the logical ports associated with the services we are working with and notice that the tags on NSX-T is the labels defined for the pods in K8s.



3. Create NSX-T NSGroup (NSX-T Security Group)

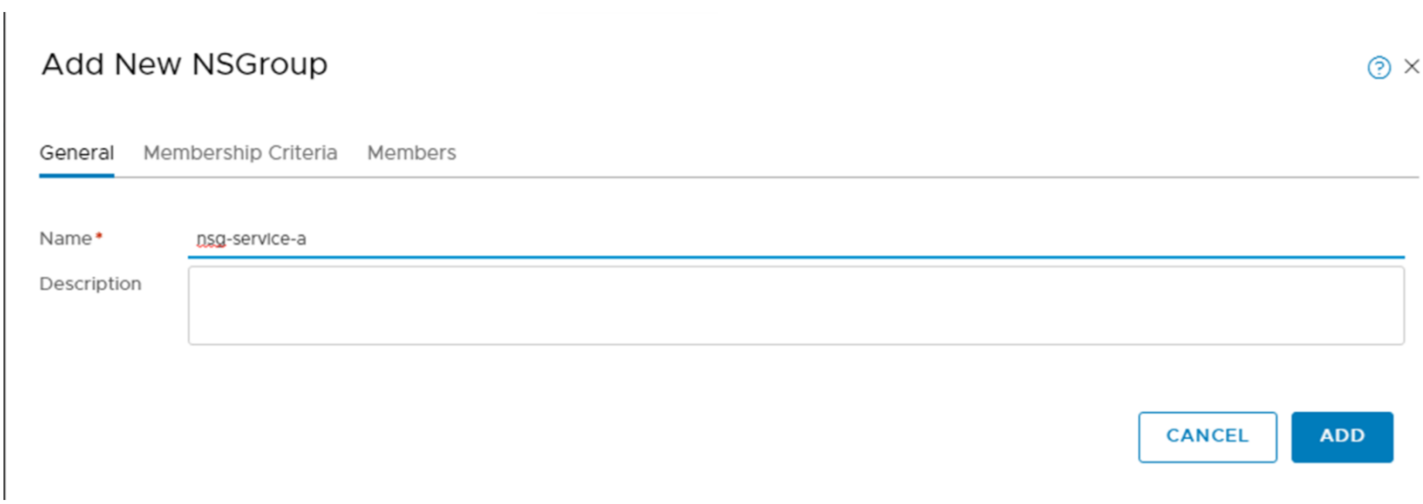
Login to NSX-T and Navigate to Advanced Networking & Security à Inventory à Groups



Create a new NSGroup by clicking on ADD

Create an NSGroup for service-a

NSGroup name – nsg-service-a



Click on Membership Critera

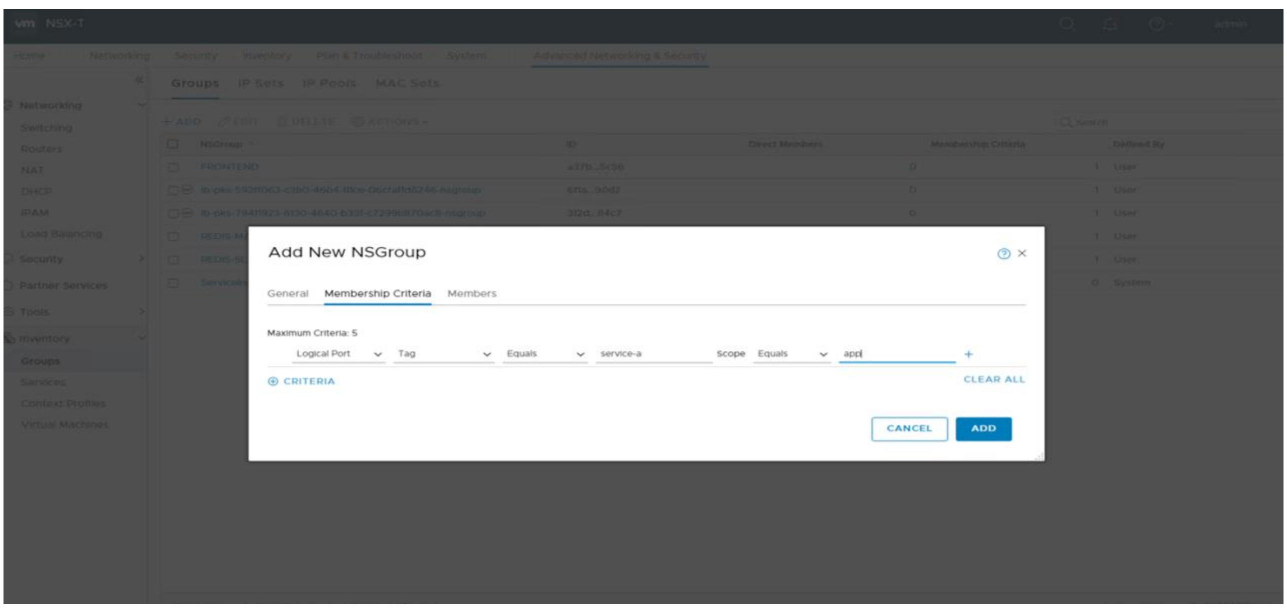
And add the following criteria
Logical Port > Tag > Equals > service-a > Scope > equals > app

Note these are the values of the tag retrieved in step 2.

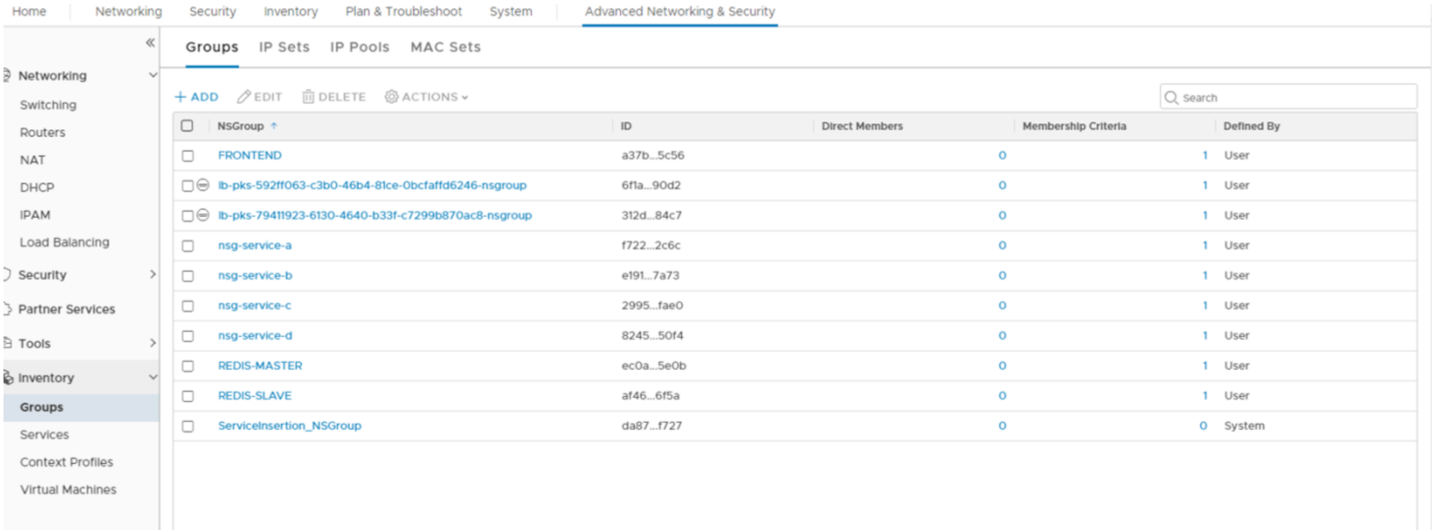
For example, if you defined a Kubernetes tag of “app=service-a” then “service-a” should be used for “Tag” value for the Logical Port and “app” should be used for the “scope”.

If you want to further refine the membership criteria to include only pods in a namespace, you can use the namespace name as the tag and scope should be defined as “ncp/project”. So for this service, the tag will be “x1” and scope “ncp/project”.

You can use multiple tags to define your membership criteria.

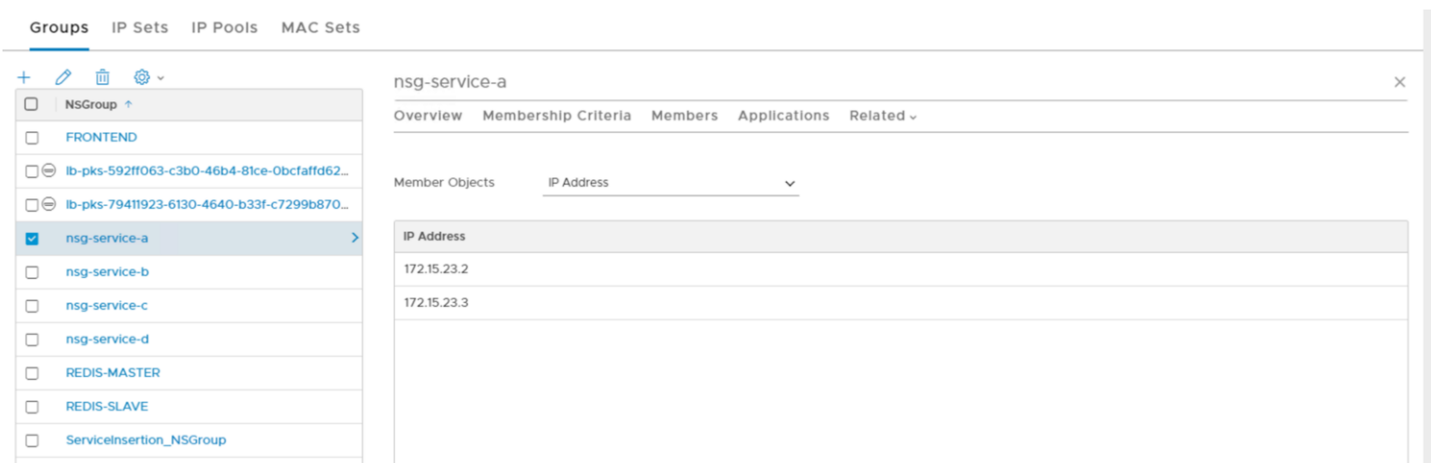


Repeat the same to create NSGroups for service-b, service-c and service-d



4. Check for pool members

Click on the newly created groups and select Members, check IP addresses



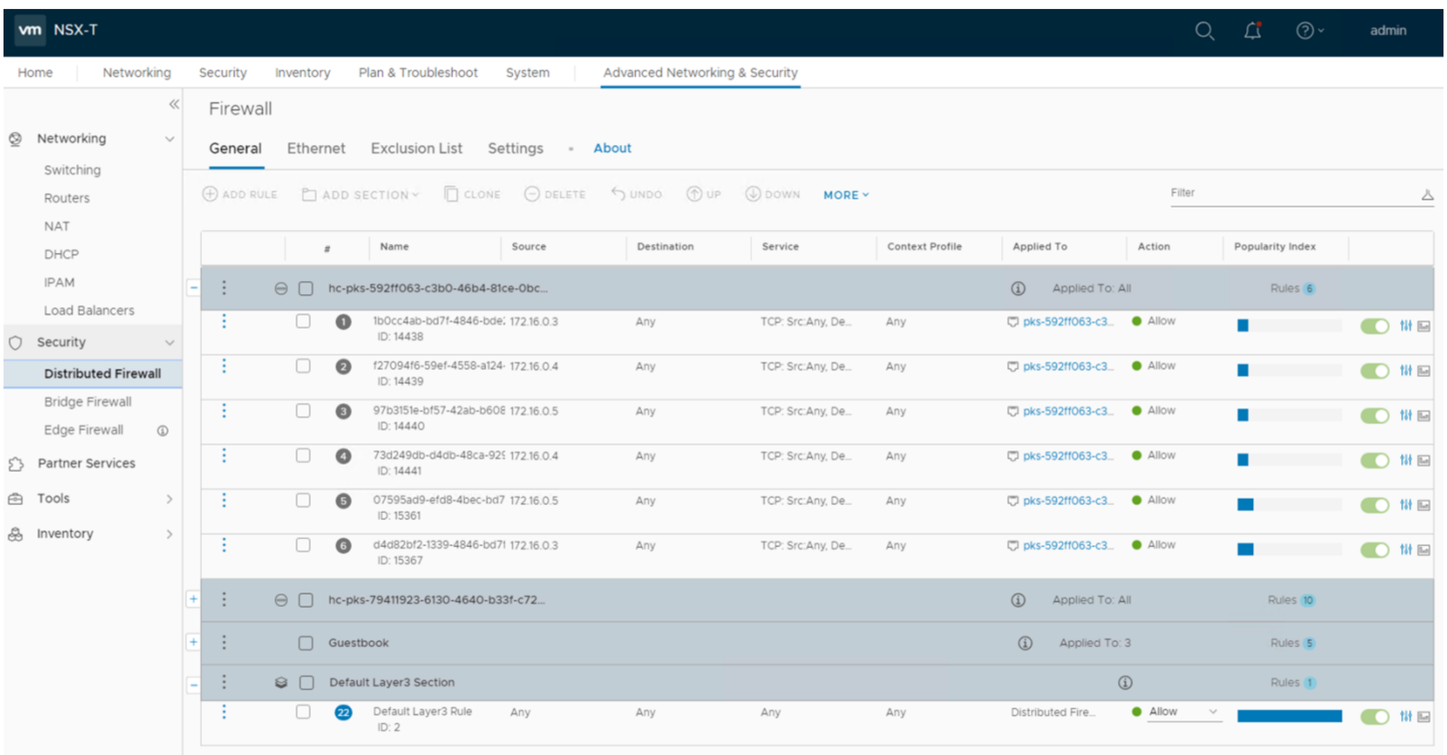
Run the following kubectl command from the terminal to verify that the ip-address match the pods ip addresses kubectl get po -n x1 -o wide

```
ubuntu@cli-vm:~/dmz$ kubectl get po -n x1 -o wide
NAME                          READY   STATUS    RESTARTS   AGE    IP            NODE                                   NOMINATED NODE   READINESS GATES
service-a-84965f57cc-nhbrx    2/2     Running   0          127m   172.15.23.3   a60cfb28-f6d8-4022-8dcb-c202aa9335c3   <none>           <none>
service-a-84965f57cc-q72fh    2/2     Running   0          127m   172.15.23.2   f9be16c4-7396-41c6-9c97-7b5280f165f0   <none>           <none>
```

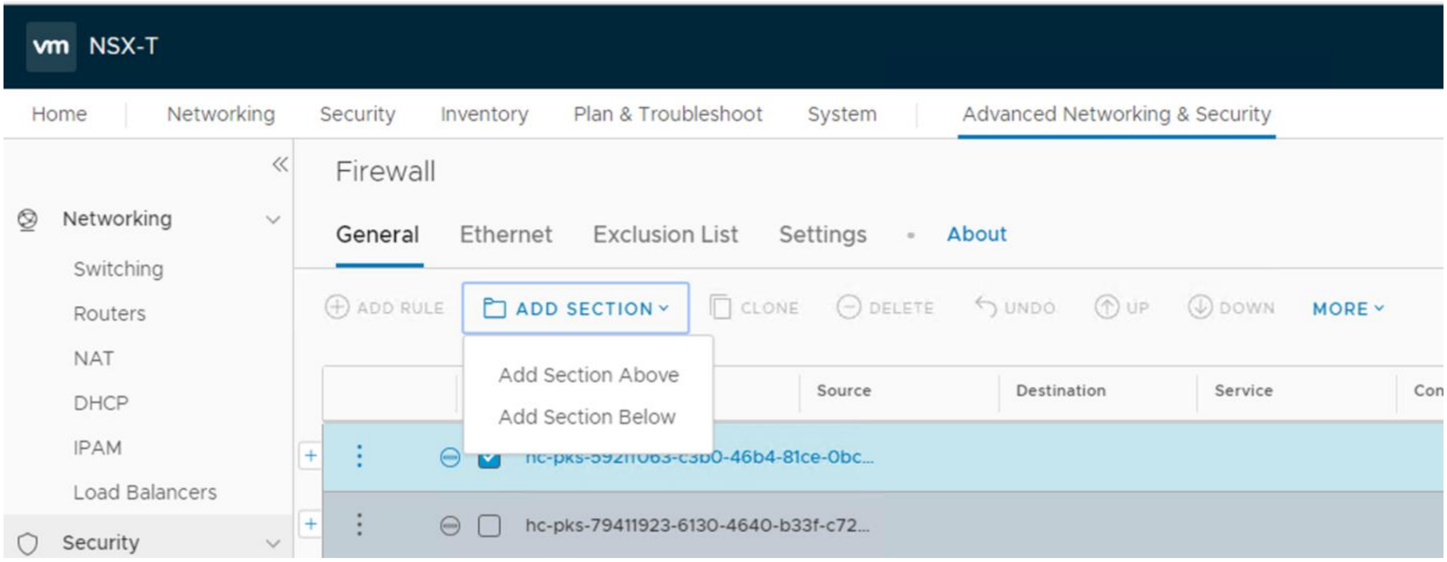
Repeat the same for the other NSGroups created

5. Create DFW rules

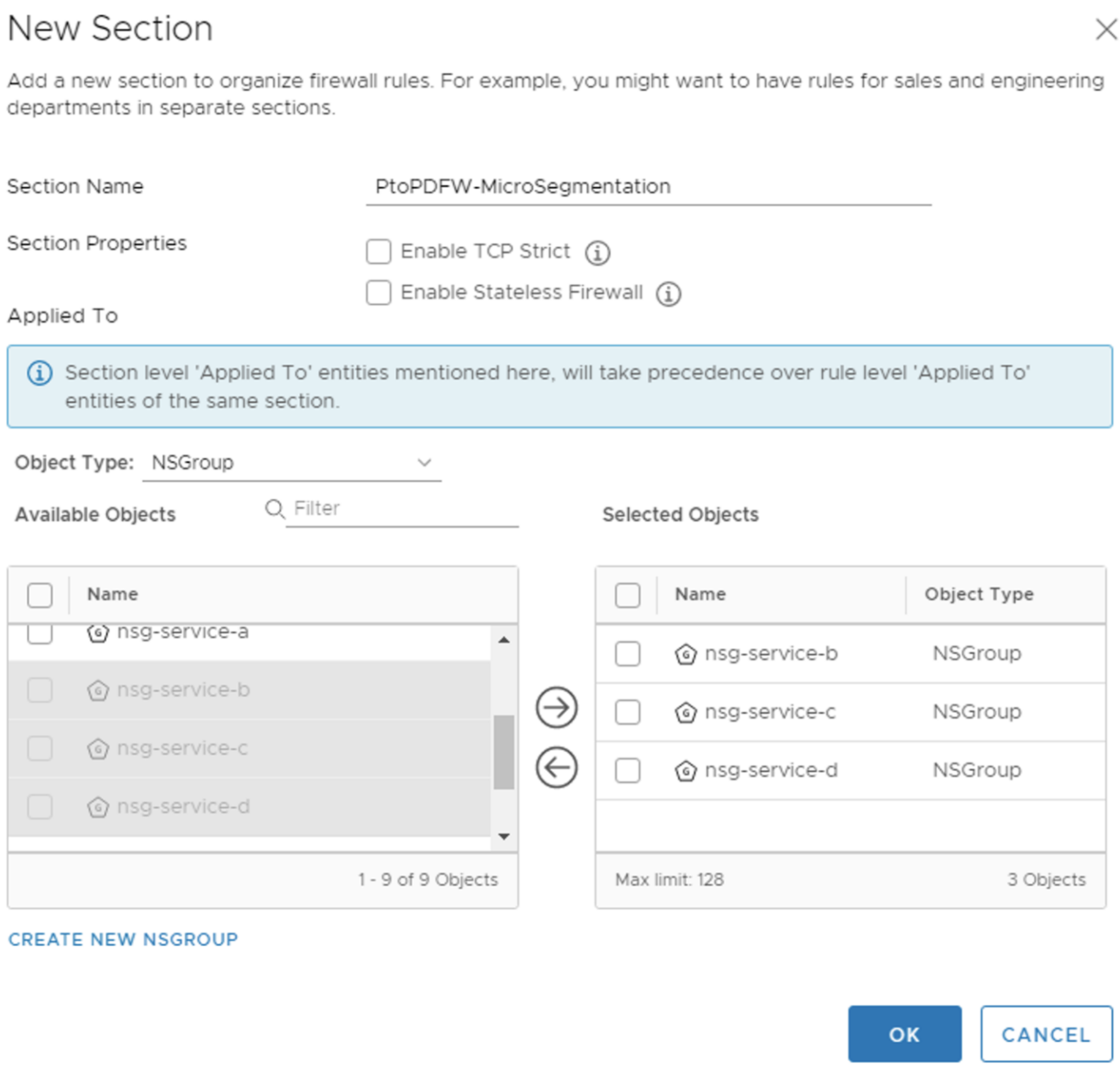
Login to NSXT and navigate to Advanced Networking & Security > Distributed Firewall



Select the first section listed and navigate to ADD SECTION à Add Section Above



Section Name – PtoPDFW-MicroSegmentation
Object Type – NSGroup
Select – nsg-service-b, nsg-service-c and nsg-service-d


New Section
Add a new section to organize firewall rules. For example, you might want to have rules for sales and engineering departments in separate sections.
Section Name
PtoPDFW-MicroSegmentation
Section Properties
Enable TCP Strict
Enable Stateless Firewall
Applied To
Section level 'Applied To' entities mentioned here, will take precedence over rule level 'Applied To' entities of the same section.
Object Type: NSGroup
Available Objects
Filter
Selected Objects
Name
nsg-service-a
nsg-service-b
nsg-service-c
nsg-service-d
1 - 9 of 9 Objects
Name
Object Type
nsg-service-b NSGroup
nsg-service-c NSGroup
nsg-service-d NSGroup
Max limit: 128
3 Objects
CREATE NEW NSGROUP
OK
CANCEL

Select the newly created PtoPDFW-MicroSegmentation segment and click on Add rule

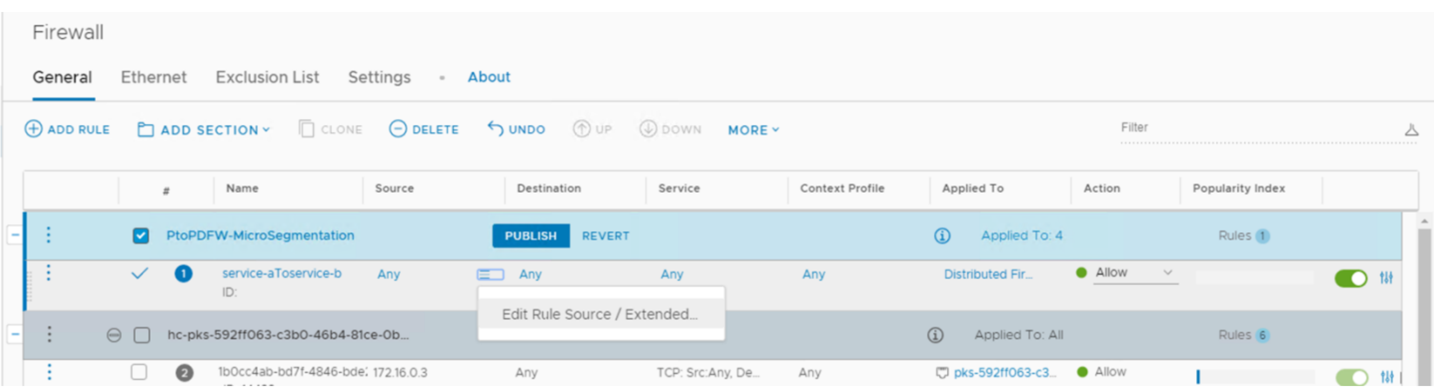
Rule 5: Denies all Traffic to nsg-service-a, nsg-service-b , nsg-service-c and nsg-service-d

ID : DenyAll
Source : Any
Destination: Any
Service: Any
ContextProfile: Any
Action : Reject

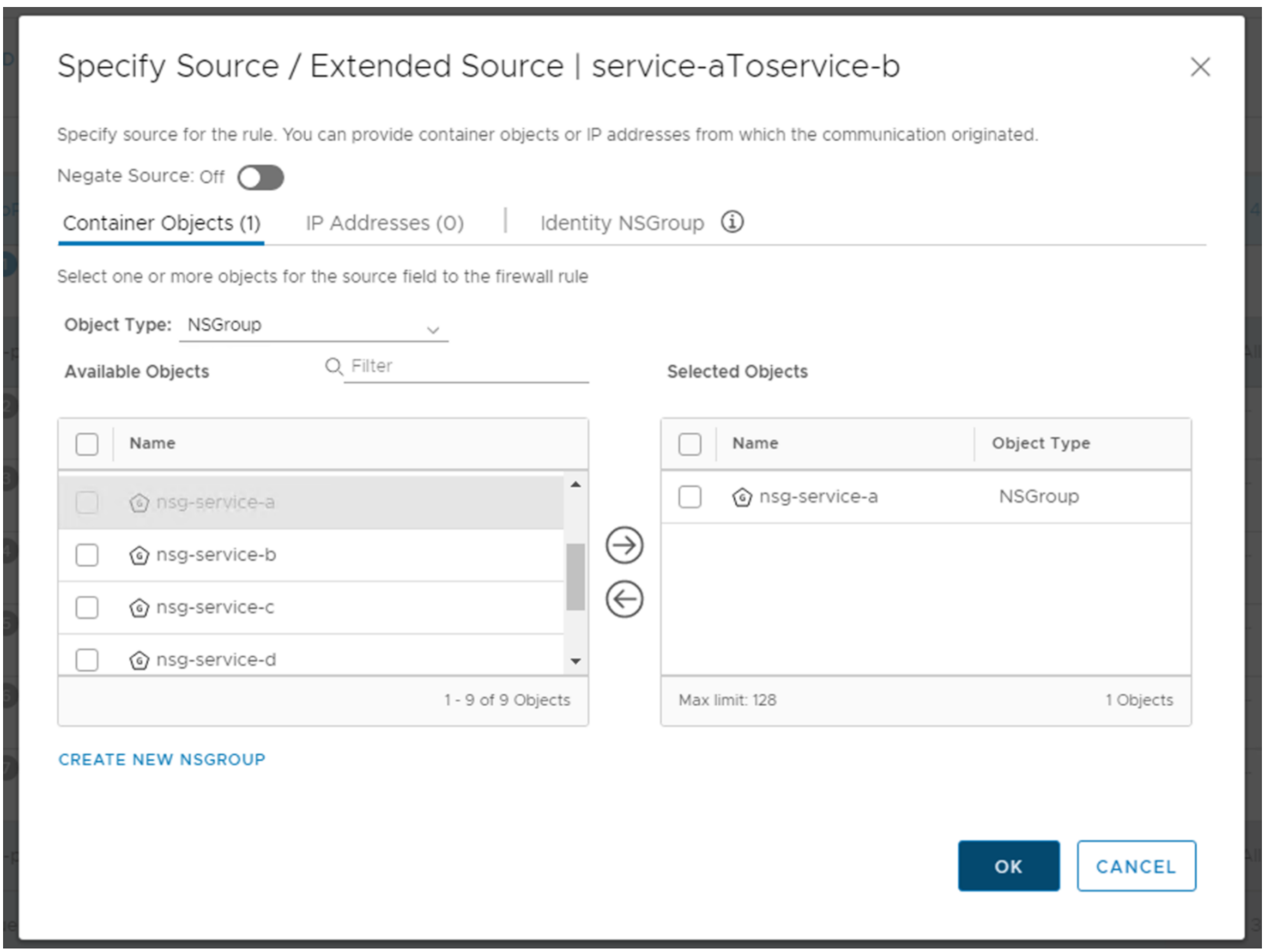
Rule 4: Allow service-a to service-b traffic

ID : service-aToservice-b
Source : nsg-service-a
Destination: nsg-service-b
Service: Any
ContextProfile: Any
Action : Allow

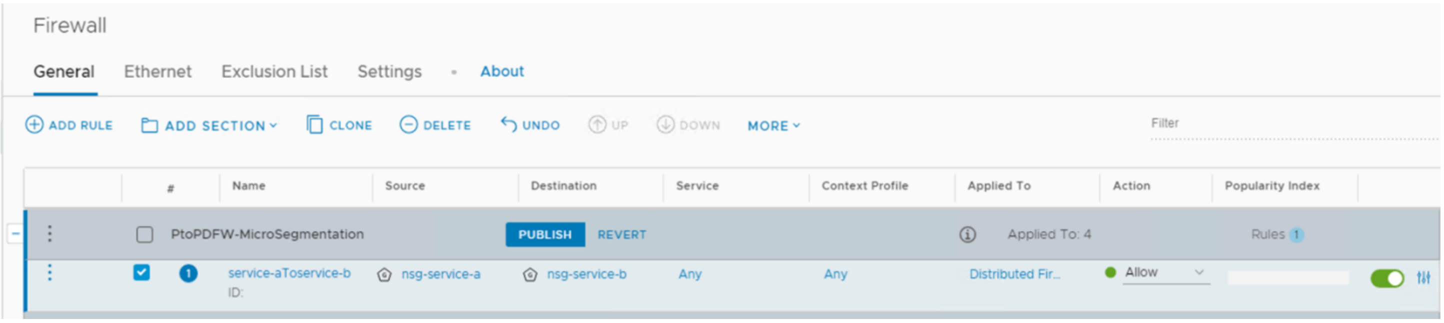
To select the Source click on the icon next to the source filed and click on Edit Rule Source



Select Object Type as NSGroup



Similarly select nsg-service-b for destination.



Rule 3: Allow service-a to service-c traffic

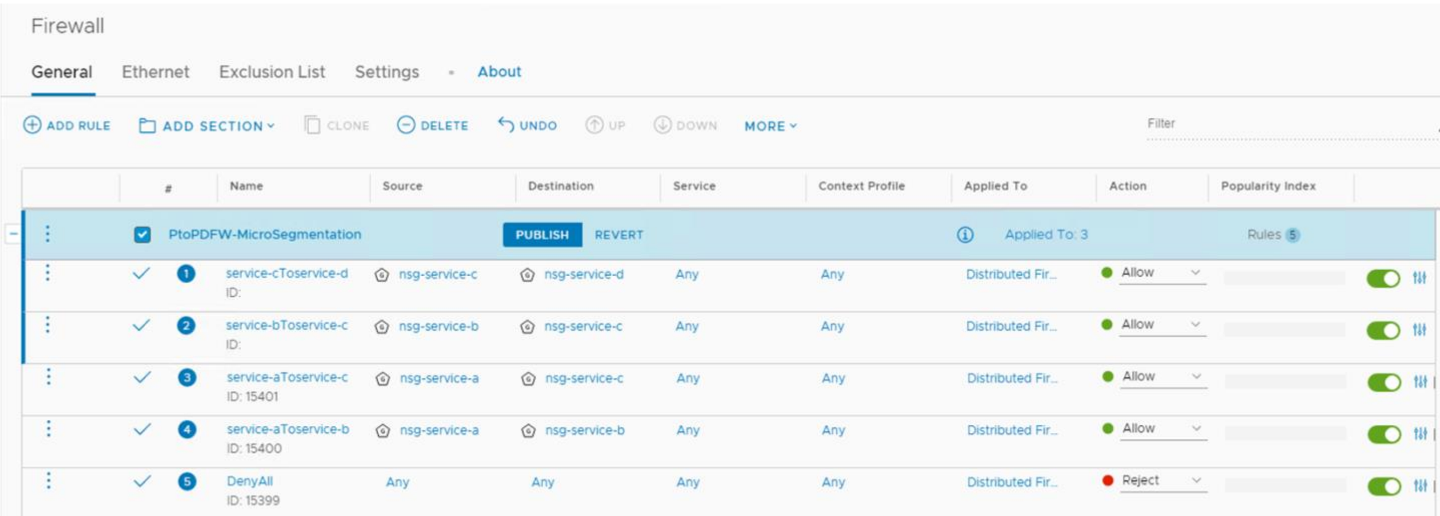
ID : service-aToservice-c
Source : nsg-service-a
Destination: nsg-service-c
Service: Any
ContextProfile: Any
Action : Allow

Rule 2: Allow service-b to service-c traffic

ID : service-bToservice-c
Source : nsg-service-b
Destination: nsg-service-c
Service: Any
ContextProfile: Any
Action : Allow

Rule 1: Allow service-c to service-d traffic

ID : service-cToservice-d
Source : nsg-service-c
Destination: nsg-service-d
Service: Any
ContextProfile: Any
Action : Allow

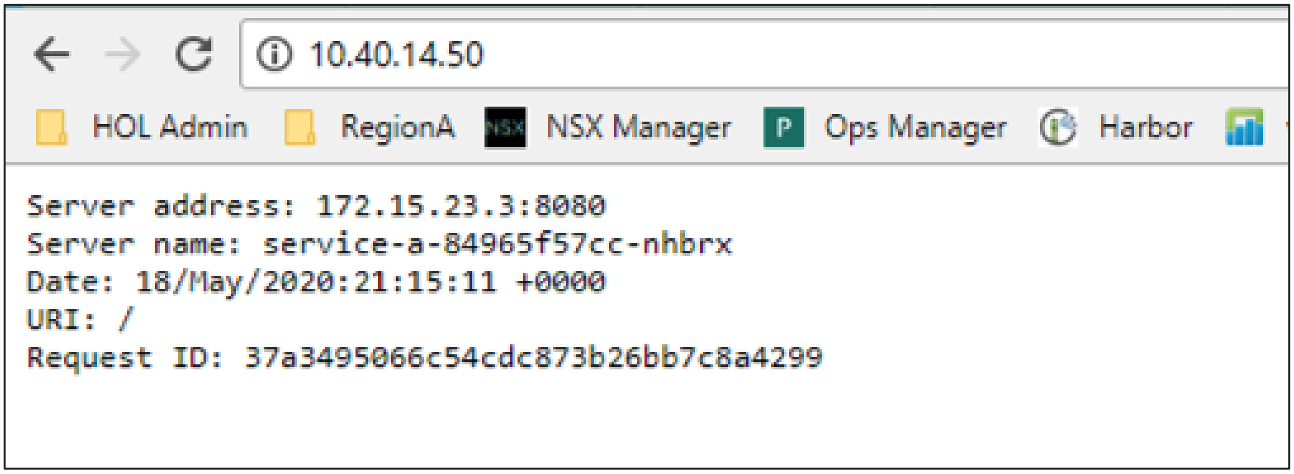


Select PtoPDFW-Microsegmentation and click on Publish

Test Traffic Flow

Traffic flow from external network to k8 cluster.

Open a browser and browse to the external ip from the previous step



service-a can be reached from the external network through the load balancer which is created in NSX-T

service-b, service-c and service-d are not exposed and hence are not reachable from the external network.

Traffic flow between pods

We will be using the busy-box container within service-a pod and use curl to check for responses between service.

Source Pod	Destination Pod	Result
service-a	service-b	Success
service-a	service-c	Success
service-a	service-d	Fail
service-b	service-c	Success
service-b	service-d	Fail

service-c	service-d	Success
service-c	service-b	Fail
service-d	service-c	Fail
service-d	service-b	Fail
service-c	service-a	Fail
service-b	service-a	Fail

1. Get pods running on namespace x1

   kubectl get po -n x1

```
ubuntu@cli-vm:~/dmz$ kubectl get po -n x1
NAME                           READY   STATUS    RESTARTS   AGE
service-a-84965f57cc-nhbrx     2/2     Running   0          31m
service-a-84965f57cc-q72fh     2/2     Running   0          31m
ubuntu@cli-vm:~/dmz$
```

2. Get service name for service-b running on namespace y1

   kubectl get svc -n y1

```
ubuntu@cli-vm:~/dmz$ kubectl get svc -n y1
NAME            TYPE        CLUSTER-IP      EXTERNAL-IP   PORT(S)   AGE
svc-service-b   ClusterIP   10.100.200.12   <none>        80/TCP    38m
```

3. Exec into the busybox container running on a service-a pod

   kubectl exec -n <namespace> <podname> -it -c busybox -- /bin/sh
   Eg

   kubectl exec -n x1 service-a-84965f57cc-nhbrx -it -c busybox -- /bin/sh

```
ubuntu@cli-vm:~/dmz$  kubectl exec -n x1 service-a-84965f57cc-nhbrx -it -c busybox -- /bin/sh
/home #
/home #
```

Use curl to reach service-b in namespace y1

   curl *http://svc-service-b.y1*

   NOTE: the service name is prepended by svc in this case, this is defined in the yaml we used to create the K8 resources. The service name is also appended by the namespace.

4. This results in a successful response

```
ubuntu@cli-vm:~/dmz$ kubectl exec -n x1 service-a-84965f57cc-nhbrx -it -c busybox -- /bin/sh
/home # curl http://svc-service-b.y1
Server address: 172.15.13.3:8080
Server name: service-b-86d8c888c7-jpwf9
Date: 18/May/2020:21:38:00 +0000
URI: /
Request ID: cfe8d330cac2894b204a1b57082e10cc
```

5. Use the curl command to check the service response of service-c in namespace z1

   curl *http://svc-service-c.z1*

   This should be successful as well

6. Use the curl command to check the service response of service-d in namespace z1

   curl *http://svc-service-d.z1*

   This would fail

```
/home # curl http://svc-service-d.z1
curl: (7) Failed connect to svc-service-d.z1:80; Connection refused
```

Exec into each pod and check connectivity between pods.

VMware, Inc. 3401 Hillview Avenue Palo Alto CA 94304 USA Tel 877-486-9273 Fax 650-427-5001 www.vmware.com.