



Transit VNet with the VM-Series 1.1

Deployment Guide

How to deploy a Transit VNet solution in Azure

<http://www.paloaltonetworks.com>

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Version History

Version number	Comments
1.1	Panorama is required for this deployment. Adds Bootstrapping to the Hub, Spoke and Autoscaling to the Spoke.

1. About

This document will guideline how to deploy a Transit VNet solution on Azure with the VM-Series. A physical Panorama or Panorama virtual appliance is required to execute this deployment. Panorama is NOT deployed in this template deployment and must be deployed separately. The Transit VNet uses a hub and spoke architecture to centralize commonly used services such as security and connectivity. The spoke architecture provides support for Azure Autoscaling using VMSS. This architecture will automatically scale out as needed while providing security for public facing workloads. For more details about the advantages of the hub and spoke topology please refer to this link:

<https://docs.microsoft.com/en-us/azure/architecture/reference-architectures/hybrid-networking/hub-spoke>

Note: The Transit VNet with the VM-Series solution is considered advanced. It requires familiarity with Azure and the VM-Series next generation firewall. This deployment has NOT been tested in Government.

The deployment guide walks through the Palo Alto Networks ARM Templates to deploy a Transit VNet solution with the VM-Series firewalls in conjunction with, Application Gateways, Standard Load Balancers, Basic Load Balancers, and User Defined Route Tables. Version 1.1 now includes support for Azure Autoscaling using Virtual Machine Scale Sets and native bootstrapping. You will need to follow the instructions in the VM-Series deployment guide on how to bootstrap in Azure Cloud.

Bootstrap the VM-Series Firewall on Azure

<https://www.paloaltonetworks.com/documentation/81/virtualization/virtualization/bootstrap-the-vm-series-firewall/bootstrap-the-vm-series-firewall-in-azure#idd51f75b8-e579-44d6-a809-2fafcfe4b3b6>

if you have any issues with this link please use the link from the main ReadMe page

Transit VNet 1.1 requires a previously deployed, physical or virtual Panorama. Panorama will be used for the spoke deployment to manage the VM-Series firewalls in the Virtual Machine Scale Set. Panorama will also be used for license deactivation, as well as logging and reporting. For more information on Panorama please see the Panorama admin guide.

Panorama Administration Guide

<https://www.paloaltonetworks.com/documentation/81/panorama>

The Transit VNet Hub provides centralized secured outbound internet access and connectivity for all your Azure VNets Spokes. This secured outbound internet access is provided by two VM-Series firewall pairs positioned behind an Azure Standard any port load balancer in the Transit Hub VNet. All outbound traffic originating from your Azure VNet spokes will be provided with a secure single point of exit from your cloud architecture by way of the Hub VNet. User Define Routes are used to route spoke traffic to the Hub internal load balancer for packet forwarding to the Hub VM-Series Firewalls. Traffic flowing through the

VM-Series is protected from inbound threats, outbound command-and-control and data exfiltration security becomes complex and cumbersome, oftentimes slowing deployments.

Azure Application Insights

In PAN-OS 8.1 support for natively publishing PAN-OS metrics to an Azure Application Insights instance was added. This allows you to monitor firewalls directly from the Azure portal. The Worker node deployed in the Transit Hub views PAN-OS published metrics via Azure Application Insights in order to determine if scaling is needed. The metrics that can be sent to Azure are

- Session Utilization %
- Total Active Sessions
- Dataplane CPU Utilization %
- Dataplane Packet Buffer Utilization %
- SSL Proxy Utilization %
- GlobalProtect Active Tunnels
- GlobalProtect Tunnel Utilization %

2. Topology

The Transit VNet solution deploys a classic hub-and-spoke architecture where the Hub and each spoke are deployed in separate VNets.

VNet Peering

For the different VNets to talk to each other, they must be peered in both the directions. VNet Peering works under the assumption that the peering networks **do not have overlapping subnets**. In this topology, when a VNet spoke is deployed, we will dynamically peer the spoke's VNet and the hub's VNet enabling traffic to flow between them. For additional information on VNet Peering please reference the link below

<https://docs.microsoft.com/en-us/azure/virtual-network/virtual-network-peering-overview>

Hub Topology

The Hub VNet consists of Mgmt , Untrust and Trust subnets. An Azure internal LB[Outbound-LB] used for outbound traffic and a pair of VM-Series FWs in an availability set. The Hub topology serves as the exit point of all non-return traffic for the Hub and Spoke topology.

The Hub topology consists of

- 2 VM-Series Firewalls
- 1 Standard internal Load Balancer
- Linux Worker Node

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- Worker node uses the Tabular storage table to keep track of the Azure VMSS table and Panorama device list. During a scale down event the worker node will deactivate the license in the Support Portal and remove the firewall from Panorama.
- The worker node updates the NAT address object in the Spoke VM-series with the correct IP address of the spoke ILB.
- The worker node will add the Azure instrumentation key for application insights into the Panorama template for each new spoke deployment.
- 1 Tabular Storage Table
 - Stores VMSS device list data

Spoke Topology

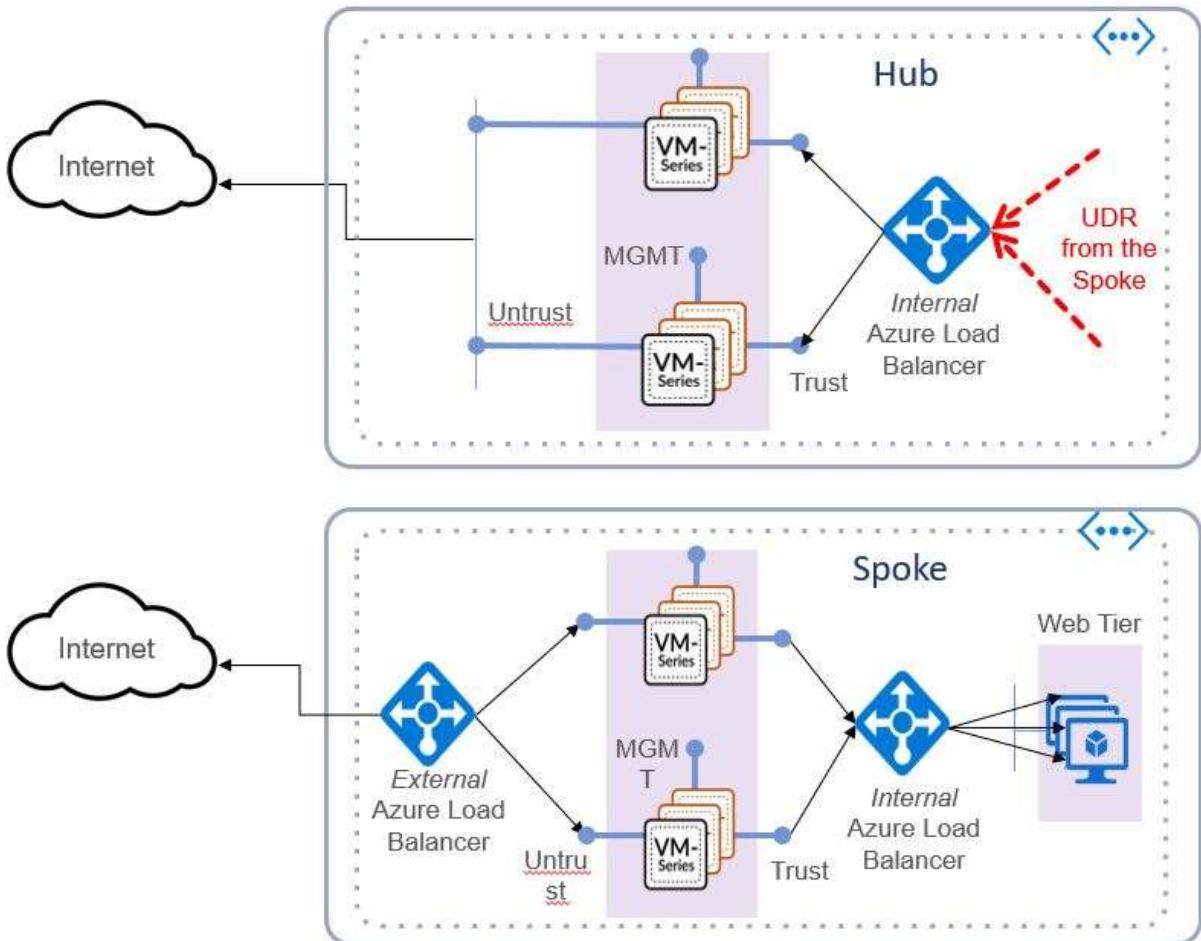
The spoke VNet allows an ingress point for all traffic destined to public facing workloads.¹ The subnets consist of Mgmt, Untrust, Trust and Backend Subnets for the application servers. An Application Gateway doubles as a public facing load balancer and sits on the front end. VM-Series firewalls in a Virtual Machine Scale Set receive traffic from the public facing LB. An Internal LB sits behind the firewalls and sends traffic to the backend application servers. All return traffic egresses this same path. When a spoke subscribes to a hub, a UDR is also defined which has a default route to the Hub's Internal Load Balancer. This is so all packets that are not destined to the spoke's VNet gets forwarded to the Hub Internal LB for routing.

The Spoke topology consists of

- 1 Application Gateway functioning as an external load balancer listening on port 80.
- Spoke subnets are 1921.168.0.0/21 Spoke1, 1921.168.8.0/21 Spoke2 and so on.
- Virtual Machine Scale Set with a VM-Series
- Availability Set for VM-Series
- 1 Internal Load Balancer
- 2 Linux Web servers
- 1 UDR sending all default route traffic to the Hub VNet Standard Load Balancer.
- 1 Bastion host
 - Used to connect to VM-Series firewalls in the VMSS via private Mgmt interface IP
- Application insights
 - Used to process VM-Series metrics used to determine scale in & scale out events

Hub & Spoke Topology

¹ The term public facing workload refers to any server reachable from the internet. Web Server etc.



3. Support Policy

Community Supported

This solution is released under an as-is, best effort, support policy. These scripts should be community supported and Palo Alto Networks will contribute our expertise as and when possible. We do not provide technical support or help in using or troubleshooting the components of the project through our normal support options such as Palo Alto Networks support teams, or ASC (Authorized Support Centers) partners and backline support options. The underlying product used (the VM-Series firewall) by the scripts or templates are still supported, but the support is only for the product functionality and not for help in deploying or using the template or script itself.

4. Prerequisites

Here are the prerequisites required to successfully launch this template:

1. Permissions

AZURE account with appropriate permissions.

2. Download appropriate files

Clone or download the files from the following GitHub repository on to your local machine:

<https://github.com/PaloAltoNetworks/Azure-transit-VNet>

3. Valid License

Without a valid VM-Series Firewall license you will not see any data in the traffic logs. If you don't have a license provided by Palo Alto Networks, please select **bundle1** or **bundle2** in the template parameters for licensing. For more information on licensing please see the link below.

<https://www.paloaltonetworks.com/documentation/81/virtualization/virtualization/license-the-vm-series-firewall>

4. Service Principal and Active Directory Application Setup

You will need to set up an Azure Active Directory application and service principal account. Follow the link below for details. Make note of your **Subscription ID**, **Azure Application ID**, **Application Secret Key**, and **Tenant ID**.

<https://docs.microsoft.com/en-us/azure/azure-resource-manager/resource-group-create-service-principal-portal#check-azure-subscription-permissions>

Retrieve Azure Tenant ID

<https://docs.microsoft.com/en-us/azure/active-directory/develop/active-directory-howto-tenant>

5. Bootstrap Storage Account

Storage accounts setup for bootstrapping in the spoke. Bootstrapping in the Hub is optional. Be sure to take the .xml configuration files from the Hub and change it to bootstrap.xml for bootstrapping. For the spoke you will not need a bootstrap.xml file because it will receive its configuration from Panorama. It is recommended to create a separate resource group for your bootstrap storage account. See bootstrap instructions below.

<https://www.paloaltonetworks.com/documentation/81/virtualization/virtualization/bootstrap-the-vm-series-firewall/bootstrap-the-vm-series-firewall-in-azure#idd51f75b8-e579-44d6-a809-2fafcfe4b3b6>

Creating the bootstrap package

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<https://www.paloaltonetworks.com/documentation/81/virtualization/virtualization/bootstrap-the-vm-series-firewall>

6. Bootstrap init-cfg.txt for Spoke VM-Series

A sample init-cfg.txt is provided below with explanation –

```
type=dhcp-client
ip-address=
default-gateway=
netmask=
ipv6-address=
ipv6-default-gateway=
hostname=
vm-auth-key=PanoramaVmAuthKey
panorama-server=PanoramaIP
panorama-server-2=
tplname=<spoke_name> + "-tmplstk"
dgname=<spoke_name> + "-dg"
dns-primary=8.8.8.8
dns-secondary=208.67.222.222
op-command-modes=
dhcp-send-hostname=yes
dhcp-send-client-id=yes
dhcp-accept-server-hostname=yes
dhcp-accept-server-domain=yes
```

7. Panorama Setup

Panorama 8.1 will be used for the spoke deployment to manage the VM-Series firewalls in the Virtual Machine Scale Set. Panorama will also be used for license deactivation, as well as logging and reporting. You must allow access to port 3978 to the Mgmt interface of the Panorama for any device security the Panorama. Port 443 and SSH can be locked down to the IP you will manage your Panorama from.

https://www.paloaltonetworks.com/documentation/81/panorama/panorama_adminguide/set-up-panorama/set-up-the-panorama-virtual-appliance#55656

8. Panorama VM Auth Key

To authenticate the API, we need a Panorama API Key. The following link will walk you through generating an API Key.

<https://www.paloaltonetworks.com/documentation/81/pan-os/xml-api/get-started-with-the-pan-os-xml-api/get-your-api-key>

9. Enabling XML API access in Panorama

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To program Panorama and deactivate VM Licenses, you need to enable XML API access in Panorama. As a best practice, create a new role with just API access to perform this. The steps to do this can be found here.

<https://www.paloaltonetworks.com/documentation/81/pan-os/xml-api/get-started-with-the-pan-os-xml-api/enable-api-access>

10. License Deactivation Key

We require a License Deactivation API Key and the “Verify Update Server Identity” to be enabled to deactivate the license keys from Panorama. The License Deactivation Key should be obtained from Palo Alto Customer Support Portal. Steps on how to activate this can be found below.

<https://www.paloaltonetworks.com/documentation/81/virtualization/virtualization/license-the-vm-series-firewall/deactivate-the-licenses/install-a-license-deactivation-api-key>

11. Panorama Template and Device Group Name

For every spoke that is launched, a corresponding Device Group, Template and Template Stack needs to be created in Panorama. Use the name of your Azure Spoke resource group to name your template and Device Group. For example, if the resource group of your spoke in Azure is named **jptvspoke1**, then name your device group **jptvspoke1-dg** and name your template stack **jptvspoke1-tmplstk**. The template should have all the configuration and added to the template stack.

Name	Description	Type	Stack	Devices
jptvspoke1		template		
jptvspoke1-tmplstk		template-stack	jptvspoke1	3g2pb000000

Name	Description	Authorization Code
Shared		
jptvspoke1-dg		

12. Panorama Device Group NAT Object

The Device Group should also have an address object called **ILB_NAT_ADDR** created with a random IP address which will be re-programmed by the worker node monitoring script.

Name	Location	Type	Address
ILB_NAT_ADDR	jptvspoke1-dg	IP Netmask	192.168.2.5/32

13. Panorama Template and Device Group Configuration

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You can use the **appgw-sample.xml** snapshot configuration in the GitHub spoke folder as an example of how to configure your device group and template in Panorama. Load this configuration on to a firewall without committing to view the settings while you configure your Panorama. To avoid issues always validate your configuration prior to attempting a push or bootstrap. See **Gotchas** section below.

5. Launch the Transit VNet Hub Template

There are multiple ways to deploy your template. You can use Azure CLI, PowerShell, Deploy to Azure button or you can deploy the template manually. If the GitHub Repository has a **Deploy to Azure** button you can deploy the template by clicking the deploy button for each template. Before launching be sure to take the **working_hub_config.xml** and rename it bootstrap.xml for use when bootstrapping VM-Series in the Hub. The steps below will walk you through how to launch the ARM template manually.



In the Azure Resource Manager console you can launch the **azureDeployInfra.json** file directly from the Azure Portal. To do this click “**New**” then search “**Template Deployment**”, click the Template Deployment icon and select “**Create**”.

A screenshot of the Microsoft Azure portal interface. The top navigation bar shows "Microsoft Azure" and "New > Marketplace > Everything". On the left, there's a sidebar with icons for "New", "Dashboard", "All resources", "Resource groups", "App Services", and "SQL databases". The main area is titled "Marketplace" and "Everything". A search bar at the top right says "Search resources, services and docs". Below the search bar, there's a "Filter" dropdown set to "Template Deployment". The results table has columns for "NAME", "PUBLISHER", and "CATEGORY". One result is listed: "Template deployment" by Microsoft, categorized under Compute.

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In the next screen click “Build your own template in the editor”

Microsoft Azure New > Marketplace > Everything > Template deployment > Custom deployment

Custom deployment
Deploy from a custom template

New

Dashboard

All resources

Resource groups

App Services

SQL databases

SQL data warehouses

Azure Cosmos DB

Virtual machines

Learn about template deployment

Read the docs

Build your own template in the editor

Common templates

Create a Linux virtual machine

Create a Windows virtual machine

Create a web app

Create a SQL database

Select “Load File”

Microsoft Azure New > Marketplace > Everything > Template deployment > Custom deployment > Edit template

Search resources, services and docs

Edit template
Edit your Azure Resource Manager template

New

Dashboard

All resources

Resource groups

Add resource

Quickstart template

Load file

Download

Parameters (0)

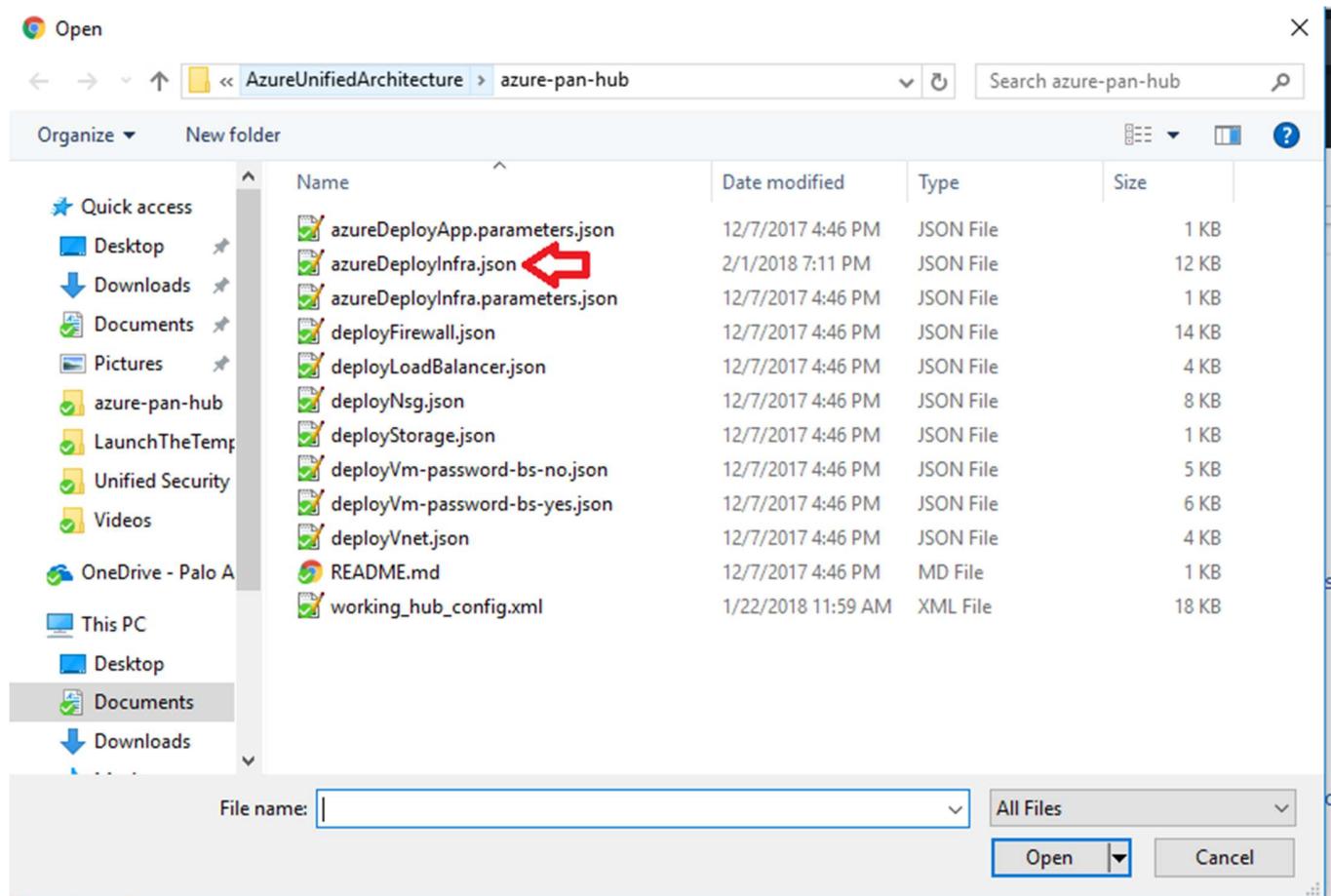
Variables (0)

Resources (0)

```
1 {
2   "$schema": "https://schema.management.azure.com/schemas/2015-01-01/deploymentTemplate.json#",
3   "contentVersion": "1.0.0.0",
4   "parameters": {},
5   "resources": []
6 }
```

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Select “**azureDeployInfra.json**” file from the Azure-Transit-VNet/azure-pan-hub directory that you cloned from GitHub, then click “Save” to bring up the parameters.



- a. Most of the **parameters** are self-explanatory and should be left at the defaults
- b. **Resource Group** – Always create a new resource Group. The hub template does not work in an existing resource group
- c. **Location** – Use the location where your bootstrap storage account is created.
- d. **Virtual Network Name** – This will be the name of the hub VNet
- e. **Virtual Network Address Prefix** – Use a network address which will not be used in the spoke deployment. The defaults should suffice.
- f. **Load Balancer IP** – Use a static IP for Load Balancer in the Trust network. Remember this address since it is used as an input parameter for the spoke template.
- g. **Network Security Group Inbound Src IP** – This is the IP you will allow explicit access to the management interface of the virtual machines. For security purposes be sure to set **Security Group Inbound IP** for mgmt access to the firewall.
- h. **Image Version** – For image version you must use at minimum PAN-OS 81.1 so select latest.
- i. **Firewall Model** – If you select BYOL you must receive licensing directly from Palo Alto Networks or reseller.
- j. **Username** and **password** that is entered by default for the devices is:
`user:pandemo password:Dem0pa$$w0rd`
- k. **Subscription ID** – See Step 4 listed in prerequisites
- l. **App ID** – See Step 4 listed in prerequisites
- m. **Tenant ID** – See Step 4 listed in prerequisites
- n. **Panorama IP** – IP address for the previously deployed Panorama
- o. **Panorama API Key** – See step 9 listed in prerequisites
- p. **Bootstrap Storage Account** – See step 5 listed in prerequisites
- q. **Storage Account Access Key** – See step 5 listed in prerequisites
- r. **Storage Account File Share** – See step 5 listed in prerequisites
- s. **Storage Account File Share Directory** – See step 5 listed in prerequisites
- t. It could take up to 10 minutes to complete the launch or longer depending on Azure.

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TEMPLATE



Customized template

9 resources



Edit template



Edit parameters



Learn more

BASICS

* Subscription

AzureTME



* Resource group

Create new Use existing

Create a resource group

* Location

East US



SETTINGS

Virtual Network Name

hub-vnet

Virtual Network Address Prefix

10.0.0.0/16

Mgmt Subnet Prefix

10.0.0.0/24

Untrusted Subnet Prefix

10.0.1.0/24

Trusted Subnet Prefix

10.0.2.0/24

Load Balancer IP

10.0.2.4

Storage Name

Enter a globally unique name

Storage Type

Standard_LRS



Mgmt Public IP Dns

Enter a globally unique name

* Network Security Group Inbound IP

Image Version

latest



Firewall Model

byol



Firewall Vm Size

Standard_D3_v2



Authentication Type

password



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Acknowledge the terms and conditions and click “Purchase”

Authentication Type <small>i</small>	<input type="text" value="password"/> <small>v</small>
Username <small>i</small>	<input type="text" value="pandemo"/>
Password <small>i</small>	<input type="text" value="....."/>
Ssh Public Key <small>i</small>	<input type="text"/>
* Subscription Id <small>i</small>	<input type="text"/>
* App ID <small>i</small>	<input type="text"/>
* App Secret <small>i</small>	<input type="text"/>
* Tenant Id <small>i</small>	<input type="text"/>
* Panorama IP <small>i</small>	<input type="text"/>
* Panorama Api Key <small>i</small>	<input type="text"/>
* License Deactivation Key <small>i</small>	<input type="text"/>
Bootstrap <small>i</small>	<input type="text" value="yes"/> <small>v</small>
Bootstrap Storage Account <small>i</small>	<input type="text"/>
Storage Account Access Key <small>i</small>	<input type="text"/>
Storage Account File Share <small>i</small>	<input type="text"/>
Storage Account File Share Directory <small>i</small>	<input type="text"/>

TERMS AND CONDITIONS

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Once the firewalls have launched, locate the **Management** interface public IP address in Azure.

outbound-vm-series0-std - Networking

Virtual machine

Search (Ctrl+ /)

Attach network interface Detach network interface

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

SETTINGS

Networking

Network Interface: **outbound-vm-series0-nic0** Effective security rules Topology

Virtual network/subnet: vnet/Mgmt Public IP: 40.67.191.216 Private IP: 10.0.0.5

INBOUND PORT RULES

Network security group nsg-mgmt (attached to subnet: Mgmt)
Impacts 1 subnets, 0 network interfaces

PRIORITY	NAME	PORT	PROTOCOL	SOURCE
----------	------	------	----------	--------

Log into the hub firewalls using **HTTPS**. Make sure your ethernet1/1 and Ethernet1/2 interfaces now show green.

Dashboard ACC Monitor Policies Objects Network Device

Ethernet Loopback Tunnel

Interface	Interface Type	Management Profile	Link State	IP Address	Virtual Router	Tag	VLAN / Virtual-Wire	Security Zone	Features	Comment
ethernet1/1	Layer3	ILBHealthCheck	Dynamic-DHCP Client	default	Untagged	none	untrust			
ethernet1/2	Layer3	ILBHealthCheck	Dynamic-DHCP Client	default	Untagged	none	trust			
ethernet1/3			none	none	Untagged	none	none			
ethernet1/4			none	none	Untagged	none	none			
ethernet1/5			none	none	Untagged	none	none			
ethernet1/6			none	none	Untagged	none	none			
ethernet1/7			none	none	Untagged	none	none			

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Verify the **virtual router** has the following configuration.

The screenshot shows the 'Virtual Router - default' configuration page. On the left, a sidebar lists options: Router Settings, Static Routes, Redistribution Profile, RIP, OSPF, OSPFv3, BGP, and Multicast. The 'Static Routes' tab is selected. The main area displays a table titled 'IPv4' with three entries:

Name	Destination	Interface	Next Hop		Admin Distance	Metric	BFD	Route Table
			Type	Value				
defaultRoute	0.0.0.0/0	ethernet1/1	ip-address	10.20.1.1	default	10	None	unicast
SpokeRoute	192.168.0.0/16	ethernet1/2	ip-address	10.20.2.1	default	10	None	unicast
HealthProbe	168.63.129.129/32	ethernet1/2	ip-address	10.20.2.1	default	10	None	unicast

At the bottom of the table are buttons for '+ Add', '- Delete', and 'Clone'. Below the table are 'OK' and 'Cancel' buttons.

DefaultRoute: is to forward all outbound traffic to the untrust interface so that it egresses out of the Azure network.

SpokeRoute: is to forward all the inbound traffic and inter-spoke traffic back to the Trust interface so that it reaches the appropriate Spoke (application server). Note that the Network address of the all the spokes VNets should be part of this network address. If a new spoke is added whose network address is not part of this network address, then a new route needs to be added in the config to forward that traffic to the Trust interface.

HealthProbe: is to respond to the health probe packets generated by the Internal Load Balancer. For this lab the health check is configured to port 22 on the firewall Trust interface.

An **allow-all** security policy is created to forward all traffic. This should be modified to accommodate your policy preferences.

The screenshot shows the 'Security Policy' table. The left sidebar lists categories: Security, NAT, QoS, Policy Based Forwarding, Decryption, Tunnel Inspection, Application Override, Authentication, and DoS Protection. The 'Policy Based Forwarding' category is selected. The main table has columns: Name, Tags, Type, Zone, Address, User, HTTP Profile, Source, Destination, Application, Service, Action, Profile, and Options.

Name	Tags	Type	Zone	Address	User	HTTP Profile	Source		Destination		Application	Service	Action	Profile	Options
							Zone	Address	Zone	Address					
1 allow_all	none	universal	any	any	any	any	any	any	any	any	any	application-d...	Allow	none	
2 intrazone-default	none	intrazone	any	any	any	any	(intrazone)	any	any	any	any	application-d...	Allow	none	
3 interzone-default	none	interzone	any	any	any	any	any	any	any	any	any	application-d...	Deny	none	

Verify that you have a **NAT rule** on the hub firewall for outbound traffic



Original Packet											Translated Packet	
Name	Tags	Source Zone	Destination Zone	Destination Interface	Source Address	Destination Address	Service	Source Translation	Destination Translation			
1 hubNatRule	none	trust	untrust	ethernet1/1	any	any	any	dynamic-ip-and-port ethernet1/1	none			

6. Launch the Transit VNet Spoke Template

Spoke Template Options

Azuredeploy.json – This launches the spoke template with VM-Series firewalls sandwiched between an external and internal load balancer. This provides secured external access to public facing workloads with return traffic egressing the spoke VNet. All internal originating traffic will be forwarded to the Hub VNet as the exit route to provide secure outbound access.

Azuredeploy-no-firewall.json – Launches the spoke template with no firewalls but still launches application servers. This scenario would NOT provide security using the VM-Series for public facing workloads. All internal originating traffic will be forwarded to the Hub VNet as the exit route to provide secure outbound access. This template will be available soon.

There are multiple ways to deploy your template. You can use Azure CLI, PowerShell, Deploy to Azure button or you can deploy the template manually. If the GitHub Repository has a **Deploy to Azure** button you can deploy your template by clicking the deploy button for each template. For the spoke you will not need a bootstrap.xml file because it will receive its configuration from Panorama. Below I will walk you through how to launch your ARM template manually.



[Deploy to Azure](#)

From the Azure-Transit-VNet/azure-pan-spoke GitHub repository that you cloned, launch the **azuredeploy.json** file directly from the Azure Portal. You may need to bring up two azure portal browsers in order to locate information needed to fill out the parameters when launching this template. To do this

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click “New” then search “Template Deployment”, click the Template Deployment icon an select “Create”.

The screenshot shows the Microsoft Azure Marketplace interface. On the left, there's a sidebar with options like 'New', 'Dashboard', 'All resources', 'Resource groups', 'App Services', and 'SQL databases'. The main area has a title bar 'Marketplace > Everything'. Below it is a search bar with the placeholder 'Search resources, services and docs'. A search result for 'Template Deployment' is shown, with a single item listed: 'Template deployment' by Microsoft, categorized under 'Compute'. A filter button 'Filter' is also visible.

In the next screen click “Build your own template in the editor”

The screenshot shows the 'Custom deployment' page in the Microsoft Azure Marketplace. The URL in the address bar is 'Microsoft Azure > New > Marketplace > Everything > Template deployment > Custom deployment'. The left sidebar is identical to the previous screenshot. The main content area has a title 'Custom deployment' with the sub-instruction 'Deploy from a custom template'. Below this, there's a section titled 'Learn about template deployment' with two links: 'Read the docs' and 'Build your own template in the editor'. A red arrow points to the 'Build your own template in the editor' link. Further down, there's a section titled 'Common templates' with four items: 'Create a Linux virtual machine', 'Create a Windows virtual machine', 'Create a web app', and 'Create a SQL database'.

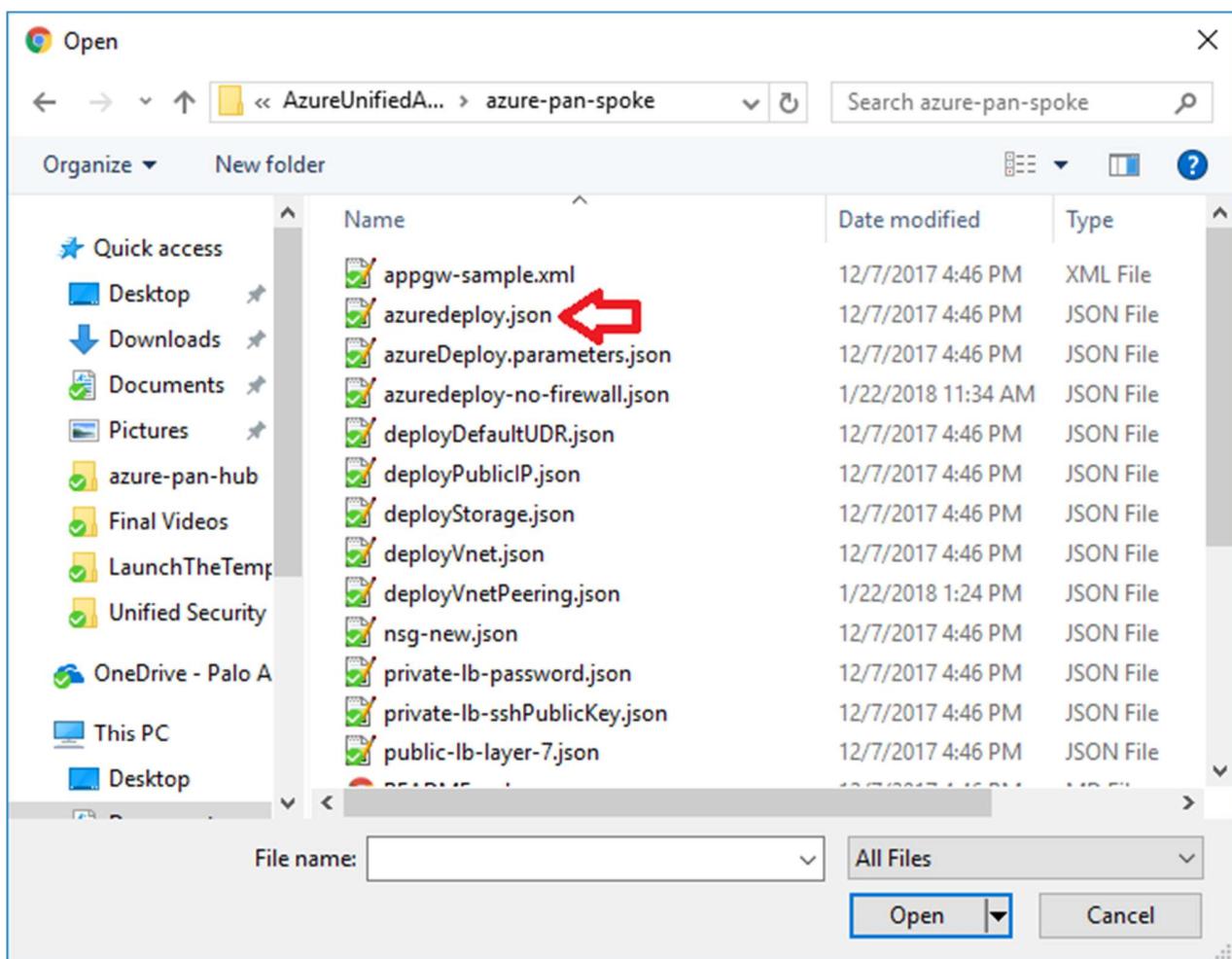
Select “Load File”

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The screenshot shows the Microsoft Azure portal's 'Edit template' interface. At the top, there's a breadcrumb navigation: Microsoft Azure > Marketplace > Everything > Template deployment > Custom deployment > Edit template. Below the navigation is a search bar with the placeholder 'Search resources, services and docs'. On the left, a sidebar has 'New' selected, followed by 'Dashboard', 'All resources', and 'Resource groups'. The main area is titled 'Edit template' with the sub-instruction 'Edit your Azure Resource Manager template'. It includes buttons for '+ Add resource', 'Quickstart template', 'Load file' (which is highlighted with a red box), and 'Download'. Under these buttons are sections for 'Parameters (0)', 'Variables (0)', and 'Resources (0)'. To the right is a code editor window displaying the beginning of an ARM template JSON file:

```
1 {  
2   "$schema": "https://schema.management.azure.com/schemas/2015-01-01/deploymentTemplate.json#",  
3   "contentVersion": "1.0.0.0",  
4   "parameters": {},  
5   "resources": []  
6 }
```

Select “azuredetect.json” file from the Azure-Transit-VNet/azure-pan-spoke directory that you cloned from GitHub, then click “Save” to bring up the parameters.



- Most of the **parameters** are self-explanatory and should be left at the defaults

- b. **Resource Group** – Create a new Resource Group. This template does not work with existing resource groups.
- c. **Location** – It should be the same location as the hub since VNet peering does not work well across regions.
- d. **Hub Resource Group Name** – Give the Resource Group name of the hub created resource group.
- e. **Hub VNet Name** – Use the exact VNet name of the hub created earlier.
- f. **Hub Load Balancer IP** – Use the static IP given to the Load Balancer in the created in the hub template. You can find this information in the load balancer settings
- g. **Network Security Group Inbound Src IP** – This is the IP you will allow explicit access to the management interface of the virtual machines.
- h. **Virtual Network Address Prefix** – This network address should be the subnet of the network address given in the “**SpokeRoute**” in the hub’s firewall configuration.
- i. **Mgmt, Trust and Untrust** subnets should be subnets of the VNet subnet created in the previous step.
- j. **Firewall VM Size** - Choose the Firewall Model and Size based on requirements. Use Standard D3 or D3 v2.
- k. **SSH Public Key** – If using a password then leave this section blank.
- l. **Bootstrap Storage Account** – See step 5 listed in prerequisites
- m. **Storage Account Access Key** – See step 5 listed in prerequisites
- n. **Storage Account File Share** – See step 5 listed in prerequisites
- o. **Storage Account File Share Directory** – See step 5 listed in prerequisites
- p. **VM Scale Set Min Count** – Customize based on preference
- q. **VM Scale Set Max Count** – Customize based on preference
- r. **Scale In Threshold** – Customize based on preference
- s. **Scale Out Threshold** – Customize based on preference
- t. **Auto Scale Metric** – Customize based on preference

For more information on Azure Virtual Machine Scale Sets please see the following link

<https://docs.microsoft.com/en-us/azure/virtual-machine-scale-sets/overview>

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Customized template
12 resources

Edit template

Edit parameters

Learn more

BASICS

* Subscription	AzureTME
* Resource group	<input checked="" type="radio"/> Create new <input type="radio"/> Use existing <input type="text" value="Create a resource group"/>
* Location	East US

SETTINGS

* Hub Resource Group Name <small>i</small>	<input type="text"/>
Hub Vnet Name <small>i</small>	hub-vnet
* Hub Load Balancer IP <small>i</small>	<input type="text"/>
Network Security Group Inbound Src IP <small>i</small>	1.1.1.1/32
Virtual Network Name <small>i</small>	spoke-vnet
Virtual Network Address Prefix <small>i</small>	192.168.0.0/21
Mgmt Subnet Prefix <small>i</small>	192.168.0.0/24
Untrusted Subnet Prefix <small>i</small>	192.168.1.0/24
Trusted Subnet Prefix <small>i</small>	192.168.2.0/24
* App Gateway Dns Name <small>i</small>	<input type="text"/>
App Gateway Subnet Prefix <small>i</small>	192.168.3.0/24
Backend Subnet Prefix <small>i</small>	192.168.4.0/24
Backend Vm Size <small>i</small>	Standard_D1_v2
Firewall Model <small>i</small>	byol
Firewall Vm Size <small>i</small>	Standard_D3_v2

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Firewall Vm Size <small>i</small>	Standard_D3_v2	▼
* Storage Account Name <small>i</small>	<input type="text"/>	
Storage Account Type <small>i</small>	Standard_LRS	▼
Username <small>i</small>	pandemo	
Authentication Type <small>i</small>	password	▼
Password <small>i</small>	*****	
Ssh Public Key <small>i</small>	<input type="text"/>	
* Bootstrap Storage Account <small>i</small>	<input type="text"/>	
* Bootstrap Storage Account Access Key <small>i</small>	<input type="text"/>	
* Bootstrap File Share <small>i</small>	<input type="text"/>	
Bootstrap Shared Dir <small>i</small>	<input type="text"/>	
Vm Scale Set Min Count <small>i</small>	1	
Vm Scale Set Max Count <small>i</small>	3	
Scale In Threshold <small>i</small>	20	
Scale Out Threshold <small>i</small>	80	
Auto Scale Metric <small>i</small>	Active Sessions	▼

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I agree to the terms and conditions stated above

Pin to dashboard

Purchase

Once the Spoke template has successfully launched you will see Deployment succeeded.

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A screenshot of the Azure portal showing a deployment success notification. The notification says: "Deployment succeeded" at 4:35 PM. It states: "Deployment 'Microsoft.Template' to resource group 'spokerg' was successful." There are two buttons at the bottom: "Go to resource group" and "Pin to dashboard".

Log into the spoke firewalls using **HTTPS**. Make sure your ethernet1/1 and Ethernet1/2 interfaces now show green

A screenshot of the Palo Alto Networks Device Manager. The top navigation bar includes Dashboard, ACC, Monitor, Policies, Objects, Network (selected), and Device. Under the Network tab, the Ethernet sub-tab is selected. A table lists the following interfaces:

Interface	Interface Type	Management Profile	Link State	IP Address	Virtual Router	Tag	VLAN / Virtual-Wire	Security Zone	Features	Comment
ethernet1/1	Layer3		Up	Dynamic-DHCP Client	default	Untagged	none	untrust		
ethernet1/2	Layer3		Up	Dynamic-DHCP Client	default	Untagged	none	trust		
ethernet1/3			Up	none	none	Untagged	none	none		
ethernet1/4			Up	none	none	Untagged	none	none		
ethernet1/5			Up	none	none	Untagged	none	none		
ethernet1/6			Up	none	none	Untagged	none	none		
ethernet1/7			Up	none	none	Untagged	none	none		

Verify the spoke firewall **virtual router** has the following configuration.

A screenshot of the Palo Alto Networks Device Manager showing the configuration of a virtual router. The left sidebar shows "Virtual Router - default" selected under "Router Settings". The main pane displays the "IPv4" tab of the "Virtual Router - default" configuration. It shows a table with one item:

Name	Destination	Interface	Type	Value	Admin Distance	Metric	BFD	Route Table
appgw	0.0.0.0/0	ethernet1/1	ip-address	192.168.1.1	default	10	None	unicast

At the bottom right are "OK" and "Cancel" buttons.

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appgw: is to forward all traffic originating from the firewall to the untrust interface. Traffic originating from spoke resources behind the firewall will egress through the Hub VNet.

An **allow-all** security policy on the firewall is created to receive all traffic although the application gateway load balancer only listens for port 80. This should be modified to accommodate your policy preferences.

Name	Tags	Type	Source				Destination				Application	Service	Action	Profile	Options
			Zone	Address	User	HIP Profile	Zone	Address	Application	Service					
1 allow_all	none	universal	any	any	any	any	any	any	any	application-d...	Allow	none	none	none	
2 intrazone-default	none	intrazone	any	any	any	any	(intrazone)	any	any	any	Allow	none	none	none	
3 interzone-default	none	interzone	any	any	any	any	any	any	any	any	Deny	none	none	none	

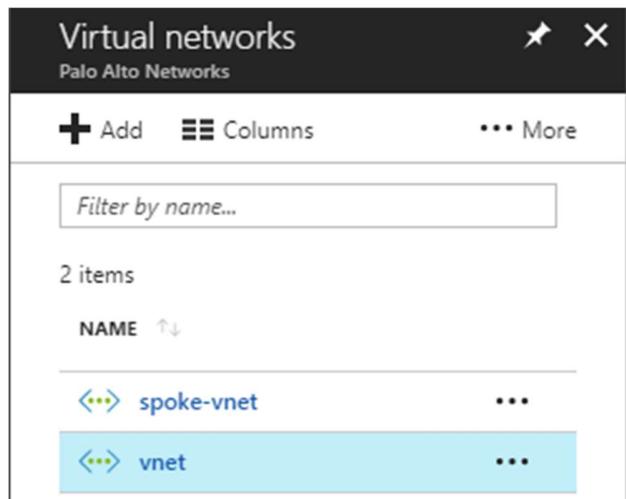
Verify that you have a **NAT rule** on the spoke firewall for inbound traffic

Name	Location	Tags	Original Packet						Translated Packet		
			Source Zone	Destination Zone	Destination Interface	Source Address	Destination Address	Service	Source Translation	Destination Translation	
1 ILB	jptvspoke1-dg	none	any	Untrust	any	any	any	any	dynamic-ip-and-port	dynamic-destination-translation	
							ethernet1/2		ethernet1/2	address: ILB_NAT_ADDR	

In order for your NAT policy to work your translated packet for source and destination should be configured as follows. **Do NOT use Static IP**

7. VNet Peering Verification

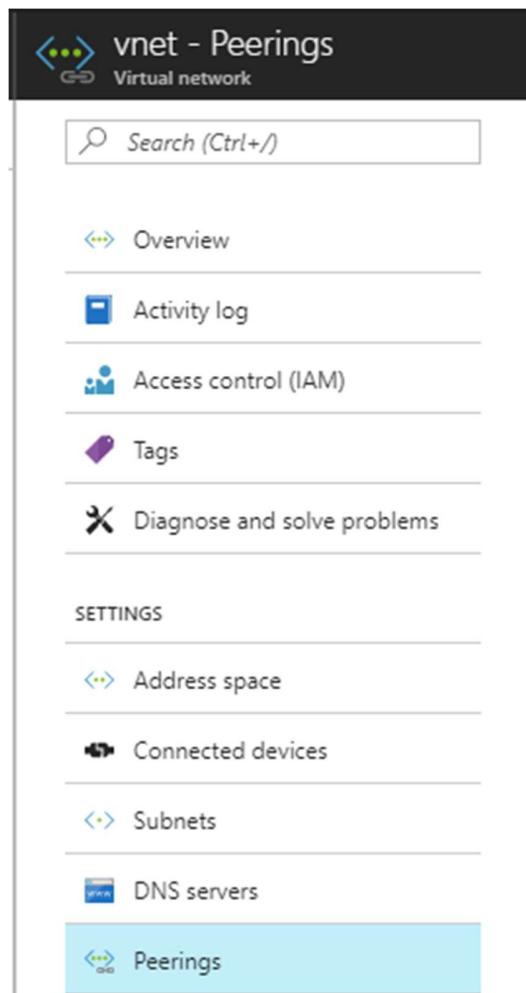
Within Azure Portal verify that **VNet Peering** has been configured automatically between the Hub VNet and Spoke VNet. To check this in Azure navigate to Virtual Networks > select the VNet name.



The screenshot shows the 'Virtual networks' blade in the Azure portal. The title bar says 'Virtual networks' and 'Palo Alto Networks'. Below the title bar are buttons for '+ Add', 'Columns', and 'More'. A search bar says 'Filter by name...'. The main area shows '2 items' listed under 'NAME'. The first item is 'spoke-vnet' and the second item is 'vnet', which is highlighted with a blue background. Each item has a 'More' button to its right.

NAME	More
spoke-vnet	...
vnet	...

Then select **Peerings**



Here you should see the name of the peer **VNet** with a status of **connected**. **Gateway Transit** should be disabled. Check this on both the hub and spoke VNet.

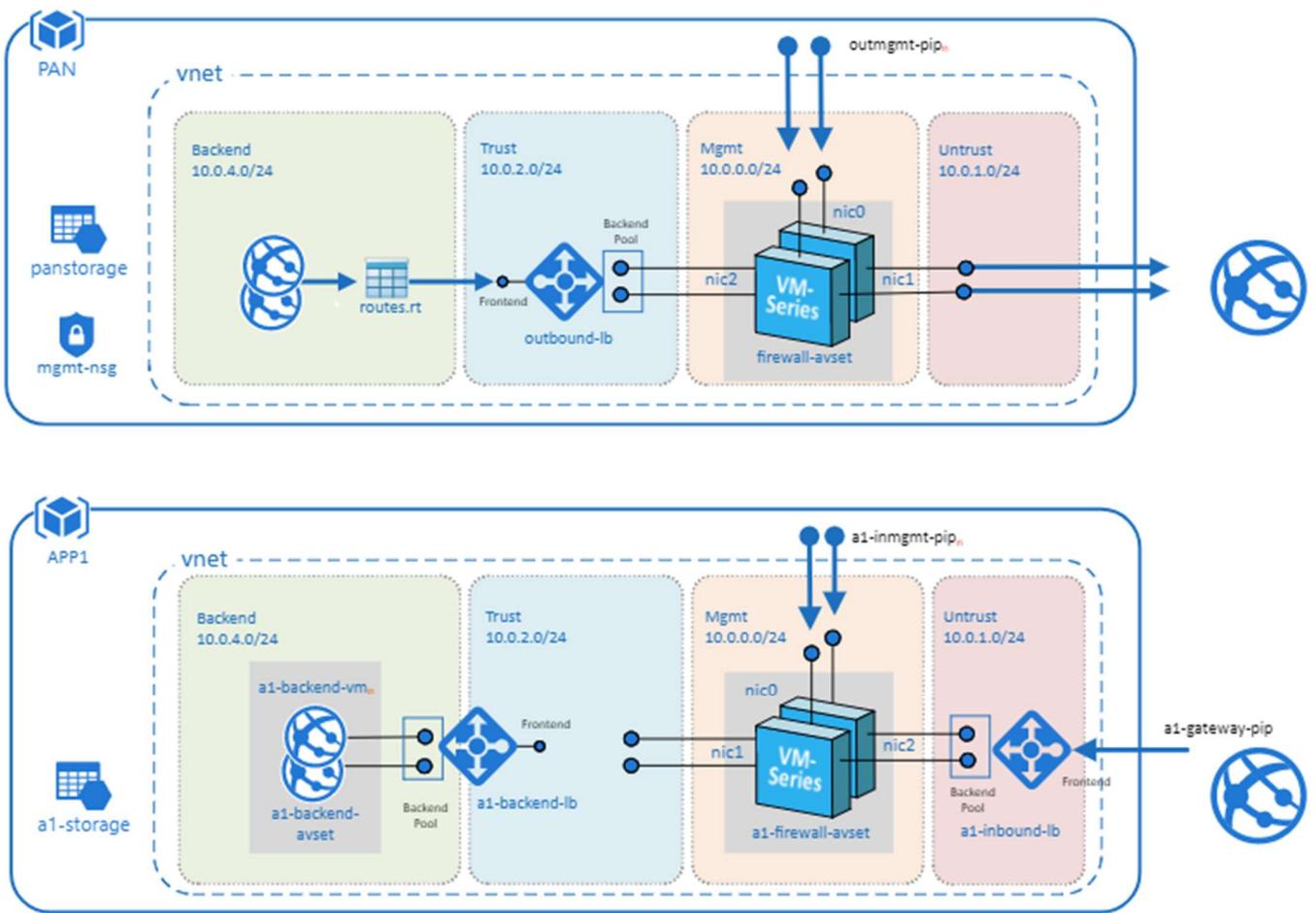
Peerings			
NAME	PEERING STATUS	PEER	GATEWAY TRANSIT
vnet-spoke-vnetvnet-peering	Connected	spoke-vnet	Disabled
			...

8. Inbound and Outbound Traffic Tests

Once you have confirmed that both the Hub and Spoke templates were successfully deployed, you have imported and loaded the firewall configuration and confirmed VNet Peering, you will want to test your proof of concept with live traffic.

Outbound Traffic Test

As per the diagram all traffic originating from within the Azure VNets will exit through the Hub VNet.



One way to test this setup is to originate traffic from a backend Linux VM deployed in the spoke to www.google.com by using wget www.google.com. From there check the traffic logs of the Hub firewalls for www.google.com traffic or web-browsing traffic if using another port 80 based website for wget tests. You will need a license to see logs in the traffic logs or you can edit the template to use PAYG1 or PAYG2.

By default you will not be able to access the Linux servers in the spoke. To access the Linux devices you will need to add a public IP address to one of the Spoke backend Linux servers. Then add a route on the UDR

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named “**defaultBackendUDR**” for mgmt traffic, that will allow your public IP address with a next hop of “Internet”

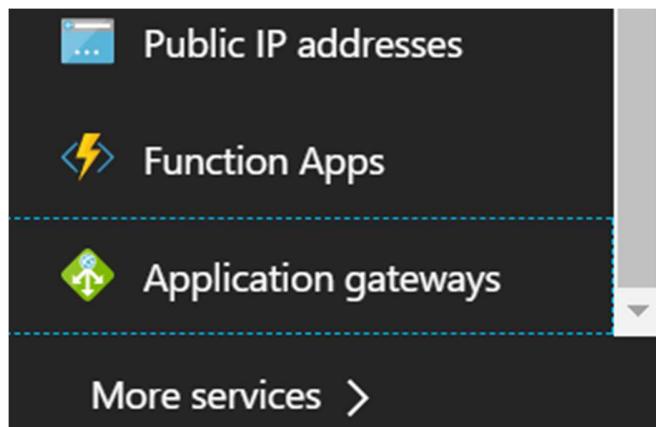
Add			
Search routes			
NAME	ADDRESS PREFIX	NEXT HOP	
defaultRoute	0.0.0.0/0	10.0.2.4	...
mgmt-traffic	.0.0/16	Internet 	...

Another way to accomplish this would be to install a **Bastion Host** or **Jump Box** into the Backend Subnet and SSH from that device.

Inbound Traffic Test

When launching the spoke template with firewalls, the spoke VNet will have an Application Gateway (External LB), A set of firewalls and an internal Load balancer. This allows the spoke to host its own public facing workloads. Once you have launched the Spoke template with firewalls you can test access to the public facing workload by

Navigating to “**Application gateways**” within the Azure Portal



Selecting the name of your **Application Gateway** that was created when you launched the Transit VNet Spoke template. You can find the name of your **Resource Group** to help you differentiate from any other Application Gateways.

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Application gateways
Palo Alto Networks

Add Columns Refresh Assign Tags

Subscriptions: 1 of 2 selected

Filter by name...	AzureTME	All resource groups	All locations
3 items			
NAME	PUBLIC IP ADDR...	PRIVATE IP ADD...	RESOURCE GROUP
<input type="checkbox"/> js-waf-appgw1	13.93.203.139	-	js-waf-appgw1
<input type="checkbox"/> myAppGw	52.165.180.7	-	spokerg 
<input type="checkbox"/> myAppGw-jtestuuuid1	104.45.230.21	-	jtestuuuid1

Locate the **Public IP address** for your Application Gateway.

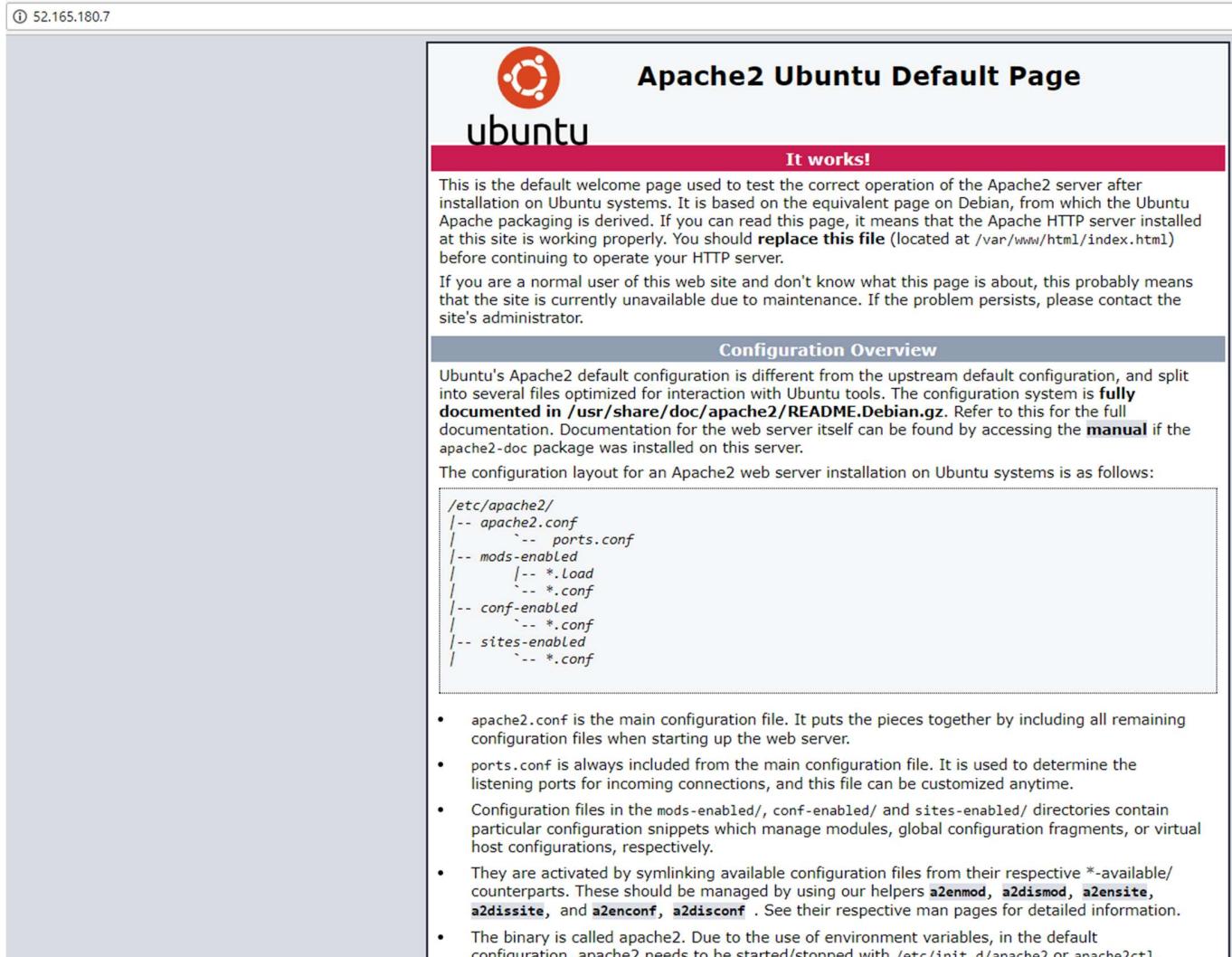
Application gateways
Palo Alto Networks

Add Columns Refresh Assign Tags

Subscriptions: 1 of 2 selected

Filter by name...	AzureTME	All resource groups	All locations
3 items			
NAME	PUBLIC IP ADDR...	PRIVATE IP ADD...	RESOURCE GROUP
<input type="checkbox"/> js-waf-appgw1	13.93.203.139	-	js-waf-appgw1
<input type="checkbox"/> myAppGw	52.165.180.7 	-	spokerg
<input type="checkbox"/> myAppGw-jtestuuuid1	104.45.230.21	-	jtestuuuid1

Place the **Public IP address** in your web browser. This IP address is the public facing IP of the Application Gateway Load Balancer. You will see the default Ubuntu Page.



The screenshot shows a web browser window displaying the Apache2 Ubuntu Default Page. The page features the Ubuntu logo and the text "ubuntu". A red banner at the top right says "It works!". Below it, a message states: "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." Another message below says: "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." A "Configuration Overview" section explains the directory structure: "/etc/apache2/", containing "apache2.conf", "ports.conf", "mods-enabled", "conf-enabled", and "sites-enabled", each with their respective configuration files. A bulleted list details the purpose of these files:

- apache2.conf is the main configuration file. It puts the pieces together by including all remaining configuration files when starting up the web server.
- ports.conf is always included from the main configuration file. It is used to determine the listening ports for incoming connections, and this file can be customized anytime.
- Configuration files in the mods-enabled/, conf-enabled/ and sites-enabled/ directories contain particular configuration snippets which manage modules, global configuration fragments, or virtual host configurations, respectively.
- They are activated by symlinking available configuration files from their respective *-available/ counterparts. These should be managed by using our helpers **a2enmod**, **a2dismod**, **a2ensite**, **a2dissite**, and **a2enconf**, **a2disconf**. See their respective man pages for detailed information.
- The binary is called apache2. Due to the use of environment variables, in the default configuration, apache2 needs to be started/stopped with /etc/init.d/apache2 or apache2ctl.

9. Cleanup

You can clean up the setup by deleting the **resource groups** for both the hub and spoke deployments. Once you have deleted the resource groups for both the hub and spoke you will have successfully deleted all resources created in this deployment.

10. Gotchas

- To successfully deploy your **spoke template**, the hub **VM-Series** firewalls must be up, running and configured or the deployment will fail. This means you must import your configuration snapshot file before launching your spoke template.

Search for deployments by name...

DEPLOYMENT NAME	STATUS	LAST MODIFIED
Microsoft.Template	! Failed (Error details)	3/21/2018, 11:51:46 AM
SetupInternalLoadBalancer	! Failed (Error details)	3/21/2018, 11:51:41 AM
SetupPublicLoadBalancer	✓ Succeeded	3/21/2018, 11:46:11 AM
SetupVNetPeering	✓ Succeeded	3/21/2018, 11:27:54 AM

- When adding a new spoke, if the subnet does not fall within the 192.168.0.0/16 pre-configured route, be sure to add the new spoke subnet to the hub firewall VM-Series static route table. Clone the spoke route configuration and change the destination route

The screenshot shows the static routes table for the IPv4 stack. The table has columns for Name, Destination, Interface, Type, Value, Admin Distance, Metric, BFD, and Route Table. There are three entries:

Name	Destination	Interface	Next Hop		Admin Distance	Metric	BFD	Route Table
			Type	Value				
defaultRoute	0.0.0.0/0	ethernet1/1	ip-address	10.0.1.1	default	10	None	unicast
SpokeRoute	192.168.0.0/16	ethernet1/2	ip-address	10.0.2.1	default	10	None	unicast
HealthProbe	168.63.129.16/32	ethernet1/2	ip-address	10.0.2.1	default	10	None	unicast

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3. **Address objects** are statically defined in the configuration snapshot file. After the deployment of the spoke, the worker node will populate this object with the correct address.

The screenshot shows the 'Objects' tab selected in the top navigation bar. A device group 'jptvspoke1-dg' is selected in the dropdown. A table displays a single row for the address object:

Name	Location	Type	Address
ILB_NAT_ADDR	jptvspoke1-dg	IP Netmask	192.168.2.5/32

4. When adding additional spokes using the firewall template you must change the spoke firewall **Default Route** to point to the untrust Azure system gateway for the subnet of the Untrust Interface.

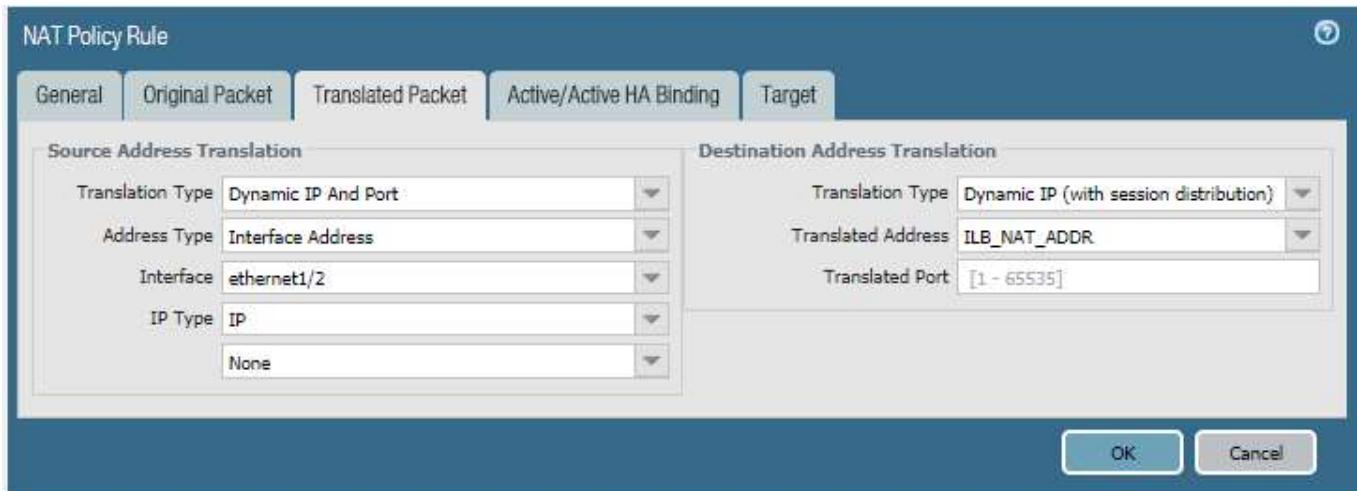
The screenshot shows the 'Virtual Router - default' configuration. On the left, a sidebar lists 'Router Settings', 'Static Routes', 'Redistribution Profile', 'RIP', 'OSPF', and 'OSPFv3'. The 'Static Routes' tab is selected. In the main pane, the 'IPv4' tab is selected, showing a table with one item:

Next Hop							
Name	Destination	Interface	Type	Value	Admin Distance	Metric	BFD
appgw	0.0.0.0/0	ethernet...	ip-address	192.168.9.1	default	10	None

5. Anytime you delete and redeploy a spoke **VNet**, it's always best practice to delete the peering configuration from within the hub VNet. The Azure system route table re-calculates after peering is established. To add new routes, you must remove the peering association, add the new routes then recreate the peering association.

SetupVNetPeering	! Failed (Error details)	3/21/2018, 12:40:02 PM	8 seconds
SetupVMSeries	✓ Succeeded	3/21/2018, 12:39:39 PM	5 minutes 58 seconds
VMSeries-Firewall-VM1	✓ Succeeded	3/21/2018, 12:39:29 PM	4 minutes 48 seconds
VMSeries-Firewall-VM0	✓ Succeeded	3/21/2018, 12:37:52 PM	3 minutes 12 seconds

6. Your **NAT policy** in Panorama will fail to push to the firewall unless your translated packet for source and destination looks like the screenshot below. For Destination do NOT use static.



7. Be sure to **never** name something on Panorama the same as what is already configured locally on the firewall. For example if you name your virtual route in the Panorama Template “default”, your Panorama push to devices will fail because the local firewall has a default virtual route. Use something like default_vr instead.

Template: jptvspoke1 View by: Device Mode: Multi VSYS; Normal Mode; VPN Enabled			
Name	Interfaces	Configuration	RIP
default_vr	ethernet1/1 ethernet1/2	Virtual System: none Static Routes: 1 ECMP status: Disabled	

8. If you are not seeing any **Metrics** being populated within the Metric view within application insights double check your instrumentation key within the Panorama Template Configuration.



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- After the VM-Series in the VMSS bootstraps it will receive the settings to connect to Panorama. Once connected the device group and template configuration will be pushed to the firewall. **After this takes place it is important to note that Panorama does NOT commit.** What this means is that after your bootstrap firewall receives its device group and template configuration it will work as designed HOWEVER a commit will still need to take place on Panorama to preserve the firewall in the device list. If a scale event takes place and a firewall is added you will know because, although the template has been pushed to the firewall it will not show in sync in panorama. See below.

Device Name	Virtual System	Model	Tags	Serial Number	Operational Mode	IP Address	Variables	Template	Status				Last Commit State	Software Version	Apps and Threat	Antivirus
									Device State	HA Status	Shared Policy	Template				
'Setup' is configured																
3g2pb000000	PA-VM	007	normal	192.168.0.5 (DHCP)	Create	jptvspoke1-implst	Connected	In sync	In sync	pre-defined	commit succeeded	8.1.0	769-4439	0		
3g2pb000001	PA-VM	007	normal	192.168.0.6 (DHCP)	Create	jptvspoke1-implst	Connected	In sync	In sync	pre-defined	commit succeeded	8.1.0	769-4439	0		
3g2pb000002	PA-VM	007	normal	192.168.0.7 (DHCP)	Create	jptvspoke1-implst	Connected	In sync	In sync	pre-defined	commit succeeded	8.1.0	769-4439	0		
3g2pb000003	PA-VM	007	normal	192.168.0.8 (DHCP)	Create	jptvspoke1-implst	Connected	In sync	In sync	pre-defined	commit succeeded	8.1.0	769-4439	0		

You will want to perform a Panorama commit to avoid an unexpected reboot which will then cause the Panorama to lose its candidate configuration.

- When issue #9 happens, you can check the worker node logs to see data. From the Hub resource group locate the worker node public IP address and log in using the pandemo user account and password.

Type \$sudo bash

Type # cd /root

Type cat worker.log | grep boot

You will see output like the following.

```
[2018-06-22 02:45:07,716] [INFO] (MainThread) VM 3g2pb000003 found in VMSS but not in Panorama. May be not yet booted.
```

- The worker node handles delicensing. You can check the /root/worker.log for information on delicensed VM's

```
[2018-06-19 21:20:13,324] [INFO] (MainThread) The following VMs need to be delicensed
[{'serial': u'007xxxxxxxxxxxx', 'hostname': u'3g2pb000001', 'name': u'007xxxxxxxxxxxx'}]
```

- You can check the worker.log for issues with API calls to Panorama as well.

13. The following output in the worker.log would signify that Panorama is not accessible or the **API key used is incorrect**

```
[2018-06-27 06:05:08,661] [INFO] (MainThread) Executed URL  
https://23.991.1341.105/api/?type=config&action=get&key=xxxxxxxxxxxxxxxxxxxxxxxxxxxxxx  
xxxxxxxxxxxxxxxxxxxxxxxxxxxxx=&xpath=/config/devices/entry[@name='localhost.lo  
caldomain']/device-group/entry[@name='jptvspoke1-dg']/devices  
[2018-06-27 06:07:18,818] [ERROR] (MainThread) Execution of cmd failed with <urlopen  
error [Errno 110] Connection timed out>  
[2018-06-27 06:07:18,819] [INFO] (MainThread) Getting device list from DG jptvspoke1-dg  
failed <urlopen error [Errno 110] Connection timed out>
```

14. If the Hub resource group worker node is powered off, the script needed to maintain the relationship between Panorama and the VMSS does not automatically restart. To restart this cronjob do the following.

```
#crontab -l  
You should see  
/tmp/monitor/monitor.py
```