



Transit VNet with the VM-Series

Deployment Guide

How to deploy a Transit VNet solution in Azure

<http://www.paloaltonetworks.com>

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Version History

Version number	Comments
1.0	Initial GitHub check-in

1. About

This document will guideline how to deploy a Transit VNet solution on Azure with the VM-Series. The Transit VNet uses a hub and spoke architecture to centralize commonly used services such as security and connectivity. 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.

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. This solution does not include native bootstrapping, so you will be provided firewall configuration files for both the Hub and Spoke firewall pairs as well as detailed steps on how to apply the configuration files. The configuration files will be applied manually after the firewalls have been deployed.

The Transit VNet provides centralized secured outbound internet access and connectivity for all your Azure VNets. This secured outbound internet access is provided by two VM-Series firewall pairs positioned behind an Azure Standard any port load balancer in the Hub VNet. All outbound traffic originating from your Azure VNets 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.

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

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

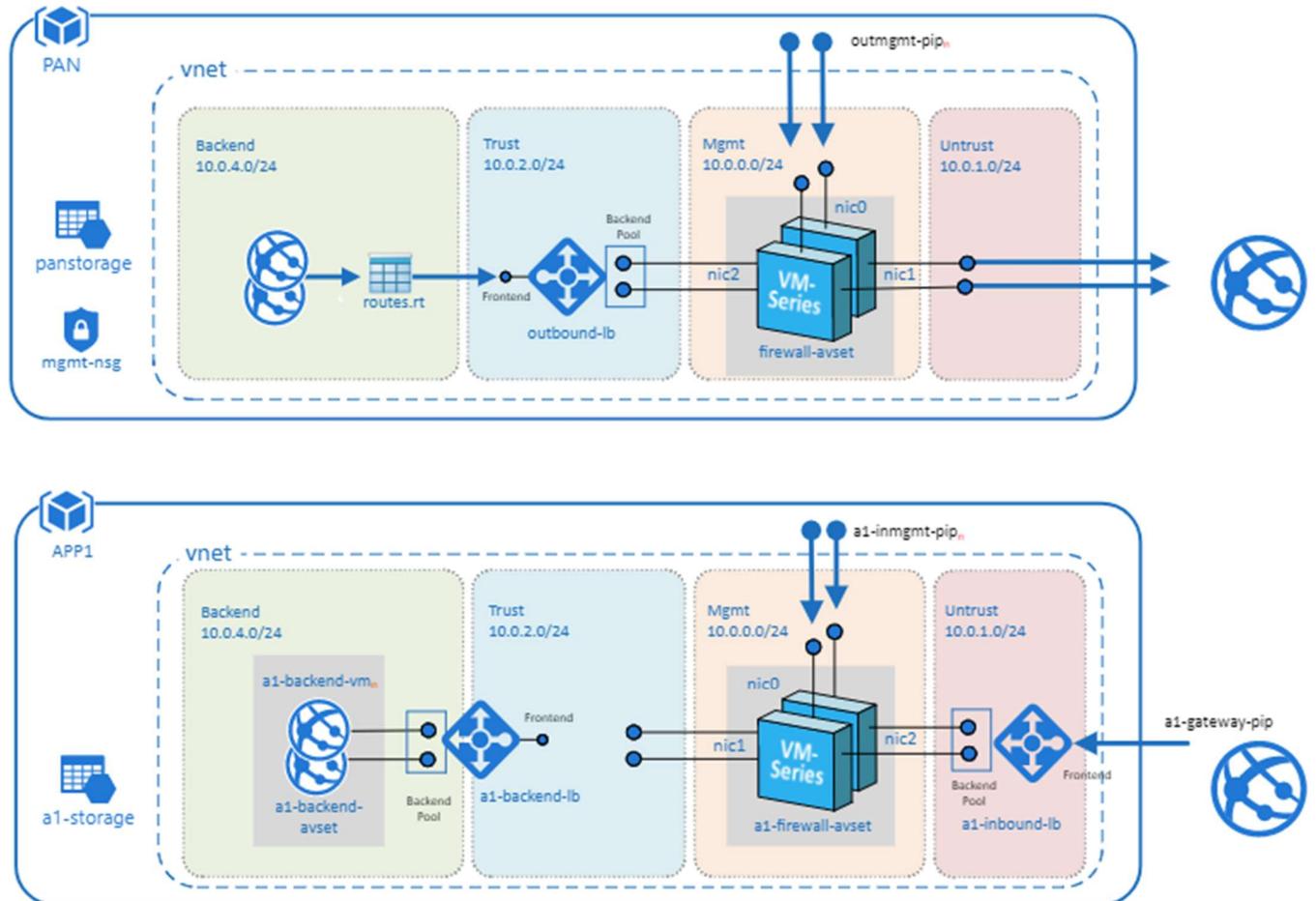


Figure 1

Hub Topology

In Figure 1 **PAN** represents the Hub VNet. 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

Spoke Topology

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In Figure 1 **APP1** represents the Spoke VNet. The spoke VNet allows an ingress point for all traffic destined to public facing resources. 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. A pair of VM-Series FWs in an availability 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 listening on port 80. The App Gateway also functions as a public facing external load balancer
- 2 VM-Series Firewalls
- 1 Internal Load Balancer
- 2 Linux Web servers
- 1 UDR sending all default route traffic to the Hub VNet Standard Load Balancer.

Hub & Spoke Topology

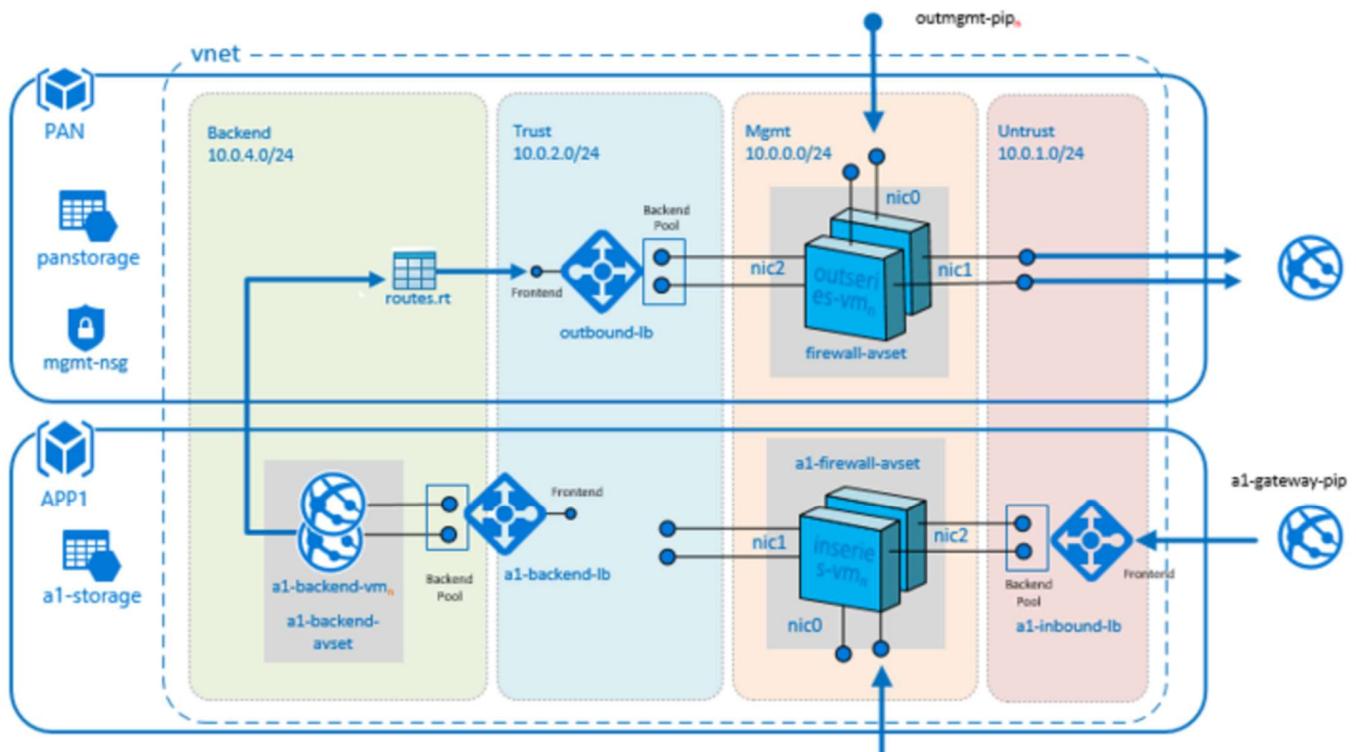


Figure 2

3. Support Policy

This solution is released under an as-is, best effort, support policy. These scripts should be seen as 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. AZURE account with appropriate permissions.
2. Clone or download the files from the following GitHub repository on to your local machine:
<https://github.com/PaloAltoNetworks/Azure-transit-VNet>
3. If the GitHub Repository has a deploy button you can deploy your templates using the button.
A blue rectangular button with a white cloud icon on the left and the text "Deploy to Azure" in white on the right.
4. **To utilize the VM-Series logging features you must have a 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/80/virtualization/virtualization/license-the-vm-series-firewall/license-typesvm-series-firewalls/vm-series-firewall-in-amazon-web-services-aws-and-azure-licenses>

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. 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 left sidebar shows navigation options like New, Dashboard, All resources, Resource groups, App Services, and SQL databases. The main area is titled 'Marketplace' and shows search results for 'Everything'. A search bar at the top right says 'Search resources, services and docs'. Below it, a filter section says 'Filter' and 'Template Deployment'. The results table has columns for NAME, PUBLISHER, and CATEGORY. One result is listed: 'Template deployment' by Microsoft, categorized under Compute.

NAME	PUBLISHER	CATEGORY
Template deployment	Microsoft	Compute

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

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The screenshot shows the Microsoft Azure portal interface. The top navigation bar includes 'New > Marketplace > Everything > Template deployment > Custom deployment'. On the left sidebar, under the 'New' section, there is a link to 'Build your own template in the editor' with a red arrow pointing to it. Below this, there are sections for 'Learn about template deployment' (with links to 'Read the docs' and 'Build your own template in the editor'), 'Common templates' (including 'Create a Linux virtual machine', 'Create a Windows virtual machine', 'Create a web app', and 'Create a SQL database'), and a list of common services like Dashboard, All resources, Resource groups, App Services, SQL databases, SQL data warehouses, Azure Cosmos DB, and Virtual machines.

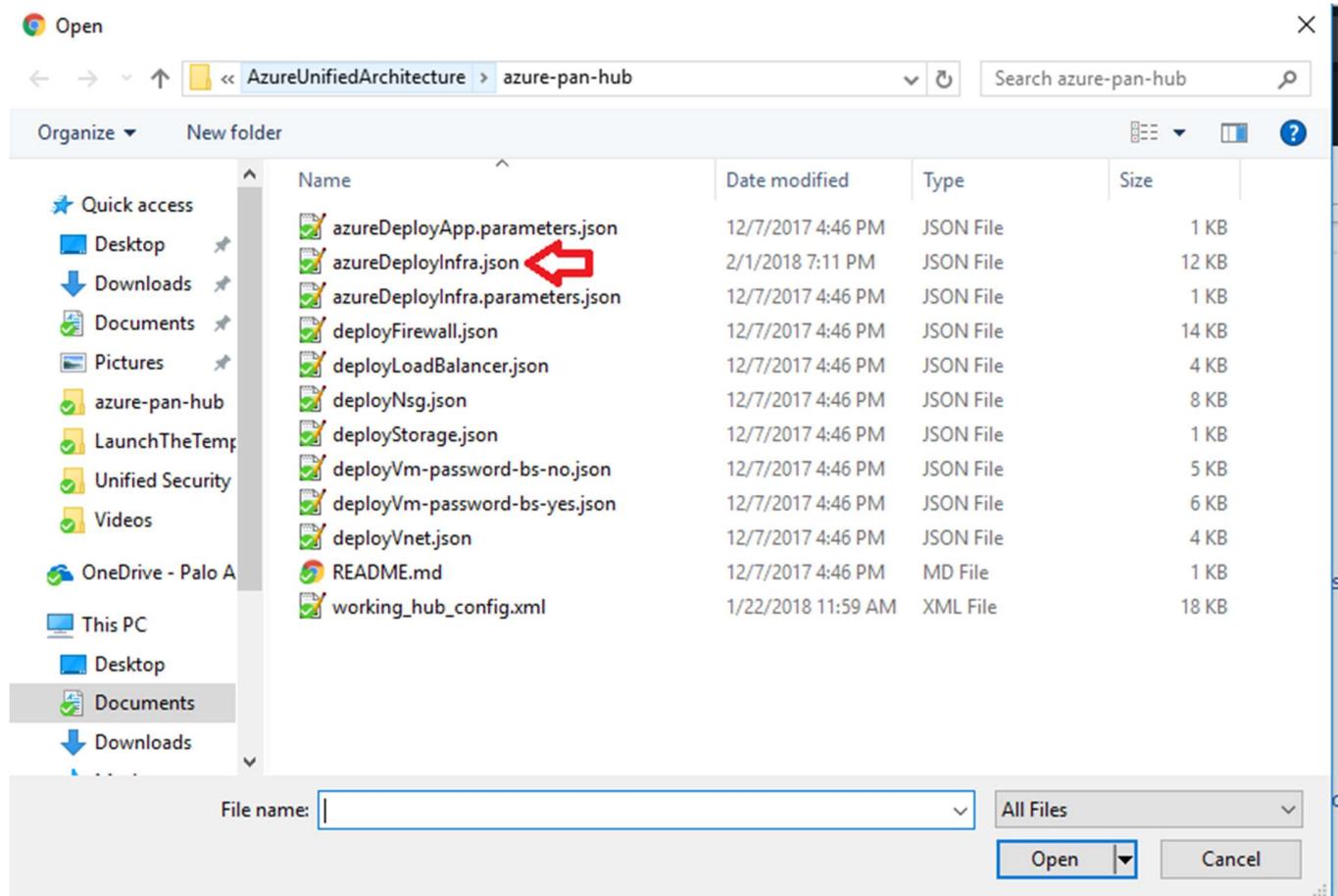
Select “Load File”

The screenshot shows the 'Edit template' page in the Microsoft Azure portal. The top navigation bar includes 'New > Marketplace > Everything > Template deployment > Custom deployment > Edit template'. The left sidebar shows 'New' options and a list of common services. The main area is titled 'Edit template' and contains a code editor with the following JSON template:

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

Palo Alto Networks Transit VNet with the VM-Series Deployment Guide

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 a location where Standard Load Balancer Preview feature is enabled. List of regions is found here - <https://docs.microsoft.com/en-us/azure/load-balancer/load-balancer-standard-overview#region-availability>
- d. **Hub Load Balancer Sku** – Use the **Standard** SKU type which will load balance all outbound TCP traffic.
- e. **Network Security Group Name** is the NSG that is attached to the Firewall's Management subnet
- f. **Network Security Group Inbound Src IP** – This is the IP you will allow explicit access to the management interface of the virtual machines.
- g. **Virtual Network Name** – Use a unique name which will not be used in the spoke VNet deployment. Remember this name since it is an input parameter for the spoke template.
- h. For security purposes be sure to set **Security Group Inbound IP** for mgmt access to the firewall.
- i. **Virtual Network Address Prefix** – Use a network address which will not be used in the spoke deployment.
- j. **Virtual Network Name** – Use a unique name which will not be used in the spoke VNet deployment. Remember this name since it is an input parameter for the spoke template.
- k. **Virtual Network Address Prefix** – Use a network address which will not be used in the spoke deployment.
- l. **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.
- m. **Firewall Model** – The template default will work unless a larger size is required.
- n. It could take up to 5 minutes to complete the launch or It could take longer depending on Azure.
- o. **Username** and **password** that is entered by default for the devices is:
user:pandemo password:Dem0pa\$\$w0rd

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Custom deployment
Deploy from a custom template

TEMPLATE

Customized template
5 resources

Edit template Edit parameters Learn more

BASICS

* Subscription: AzureTME

* Resource group: Create new (radio button selected) Use existing
Create a resource group

* Location: Central US

SETTINGS

Hub Load Balancer Sku: Standard

Storage Name: Enter a globally unique name

Mgmt Public IP Dns: Enter a globally unique name

Network Security Group Name: nsg

Network Security Group Inbound IP: 0.0.0.0/0 

Av Set Name: outbound-avset

Storage Type: Standard_LRS

Virtual Network Name: vnet

Virtual Network Address Prefix: 10.0.0.0/16

Mgmt Subnet Name: Mgmt

Mgmt Subnet Prefix: 10.0.0.0/24

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Acknowledge the terms and conditions and click “Purchase”

Untrusted Subnet Name 	Untrust
Untrusted Subnet Prefix 	10.0.1.0/24
Trusted Subnet Name 	Trust
Trusted Subnet Prefix 	10.0.2.0/24
Mgmt Public IP Name 	mgmt-pip
Load Balancer Name 	outbound-lb
Load Balancer IP 	10.0.2.4
Firewall Model 	byol  use bundle1 or bundle2 if you do NOT have a byol license.
Firewall Vm Name 	outbound-vm-series
Firewall Vm Size 	Standard_D3_v2
Authentication Type 	password
Username 	pandemo
Password 
Ssh Public Key 	

TERMS AND CONDITIONS

this template. Prices and associated legal terms for any Marketplace offerings can be found in the [Azure Marketplace](#); both are subject to change at any time prior to deployment.

Neither subscription credits nor monetary commitment funds may be used to purchase non-Microsoft offerings. These purchases are billed separately.

If any Microsoft products are included in a Marketplace offering (e.g. Windows Server or SQL Server), such products are licensed by Microsoft and not by any third party.

I agree to the terms and conditions stated above

Pin to dashboard

Purchase

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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+ /)

Overview

Activity log

Access control (IAM)

Tags

Diagnose and solve problems

SETTINGS

Networking

Attach network interface Detach network interface

outbound-vm-series0-nic1-std outbound-vm-series0-nic0 outbound-vm-series0-nic2

Network Interface: outbound-vm-series0-nic0

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**. Locate the **working_hub_config.xml** configuration snapshot and import this configuration into both firewalls. This is in the Hub directory that you exported from GitHub.

Dashboard ACC Monitor Policies Objects Network Device

Management Operations Services Interfaces Telemetry Content-ID WildFire Session HSM

Configuration Management

Revert Revert to last saved configuration
Revert to running configuration
Save Save named configuration snapshot
Save candidate configuration
Load Load named configuration snapshot
Load configuration version
Export Export named configuration snapshot
Export configuration version
Export device state
Import Import named configuration snapshot
Import device state

Import Named Configuration

Import File Select a file Browse... OK Cancel

Open

azure-pan-hub

Name	Date modified	Type	Size
azureDeployApp.parameters.json	12/7/2017 4:46 PM	JSON File	1 KB
azureDeployInfra.json	2/1/2018 7:11 PM	JSON File	12 KB
azureDeployInfra.parameters.json	12/7/2017 4:46 PM	JSON File	1 KB
deployFirewall.json	12/7/2017 4:46 PM	JSON File	14 KB
deployLoadBalancer.json	12/7/2017 4:46 PM	JSON File	4 KB
deployNsg.json	12/7/2017 4:46 PM	JSON File	8 KB
deployStorage.json	12/7/2017 4:46 PM	JSON File	1 KB
deployVm-password-bs-no.json	12/7/2017 4:46 PM	JSON File	5 KB
deployVm-password-bs-yes.json	12/7/2017 4:46 PM	JSON File	6 KB
deployVnet.json	12/7/2017 4:46 PM	JSON File	4 KB
README.md	12/7/2017 4:46 PM	MD File	1 KB
working_hub_config.xml	1/22/2018 11:59 AM	XML File	18 KB

File name: working_hub_config.xml Open Cancel

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Once you load the configuration and commit the changes make sure your ethernet1/1 and Ethernet1/2 interfaces now show green.

Interface	Interface Type	Management Profile	Link State	IP Address	Virtual Router	Tag	VLAN / Virtual-Wire	Security Zone	Features	Comment
ethernet1/1	Layer3	ILBHealthCheck	Up	Dynamic-DHCP Client	default	Untagged	none	untrust		
ethernet1/2	Layer3	ILBHealthCheck	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 **virtual router** has the following configuration.

Name	Destination	Interface	Type	Value	Admin Distance	Metric	BFD	Route Table
defaultRoute	0.0.0.0/0	ethernet1/1	ip-address	10.20.1.1	default	10	None	unicast
SpokeRoute	192.168.0.0/24	ethernet1/2	ip-address	10.20.2.1	default	10	None	unicast
HealthProbe	168.63.129.0/24	ethernet1/2	ip-address	10.20.2.1	default	10	None	unicast

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

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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.

Name	Tags	Type	Source				Destination				Application	Service	Action	Profile	Options
			Zone	Address	User	HIP Profile	Zone	Address	Application	Service	Action	Profile	Options		
1	allow_all	none	universal	any	any	any	any	any	application-d...	Allow	none	none			
2	intrazone-default	none	intrazone	any	any	any	(intrazone)	any	any	Allow	none	none			
3	intrazone-default	none	interzone	any	any	any	any	any	any	Deny	none	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	trust	untrust	ethernet1/1	any	any	any	dynamic-ip-and-port	none	ethernet1/1

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.

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. Below I will walk you through how to launch your ARM template manually.



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

A screenshot of the Microsoft Azure portal interface. The left sidebar shows navigation options like New, Dashboard, All resources, Resource groups, App Services, and SQL databases. The main area is titled 'Marketplace' with a search bar at the top. The search term 'Template Deployment' is entered. A table titled 'Results' lists one item: 'Template deployment' by Microsoft, categorized under Compute. The table has columns for NAME, PUBLISHER, and CATEGORY.

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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

Edit template
Edit your Azure Resource Manager template

New

- Dashboard
- All resources
- Resource groups

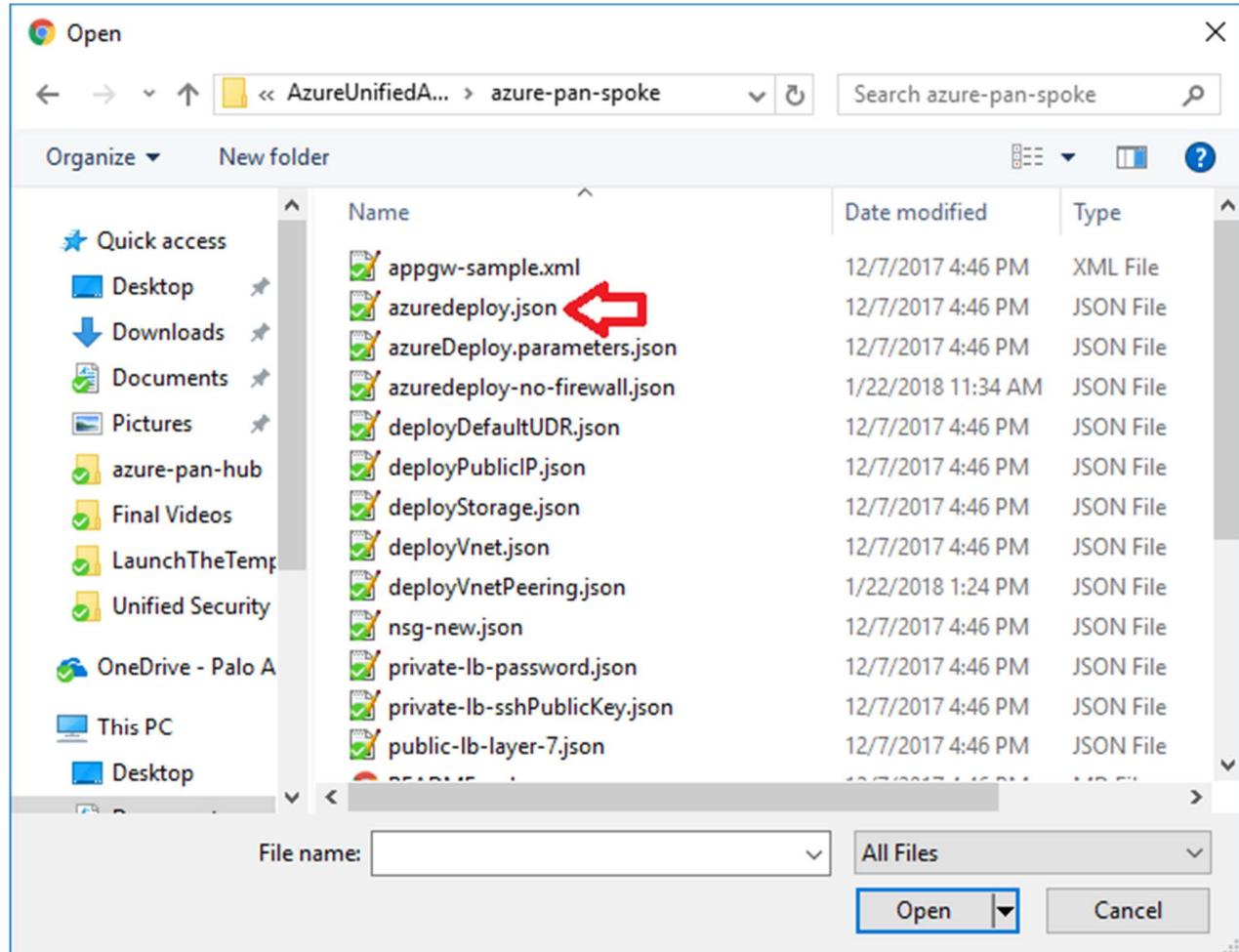
Add resource Quickstart template Load file Download

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



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- a. 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 Name** – The security group name for mgmt access
- h. **Network Security Group Inbound Src IP** – This is the IP you will allow explicit access to the management interface of the virtual machines.
- i. **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.
- j. **Mgmt, Trust and Untrust** subnets should be subnets of the VNet subnet created in the previous step.
- k. **Firewall VM Size** - Choose the Firewall Model and Size based on requirements. Use Standard D3 or D3 v2.
- l. **SSH Public Key** – If using a password then leave this section blank.

Palo Alto Networks Transit VNet with the VM-Series Deployment Guide

Custom deployment
Deploy from a custom template

BASICS

* Subscription: AzureTME

* Resource group: Create new (selected) / Use existing
Create a resource group

* Location: Central US

SETTINGS

* Hub Resource Group Name: hubrg ✓

Hub Vnet Name: hubvnet

* Hub Load Balancer IP: 10.0.2.4 ✓

Network Security Group Name: nsg-mgmt

Network Security Group Inbound Src IP: 0.0.0.0/0

Virtual Network Name: spoke-vnet

Virtual Network Address Prefix: 192.168.0.0/16

Mgmt Subnet Name: Mgmt

Mgmt Subnet Prefix: 192.168.0.0/24

Untrusted Subnet Name: Untrust

Untrusted Subnet Prefix: 192.168.1.0/24

Trusted Subnet Name: Trust

Trusted Subnet Prefix: 192.168.2.0/24

App Gateway Name: myAppGw

* App Gateway Dns Name:

Palo Alto Networks Transit VNet with the VM-Series Deployment Guide

App Gateway Subnet Name 	AppGWSubnet
App Gateway Subnet Prefix 	192.168.3.0/24
Internal Load Balancer Name 	myPrivateLB
Backend Subnet Name 	backendSubnet
Backend Subnet Prefix 	192.168.4.0/24
Backend Vm Size 	Standard_D1
Firewall Model 	byol
	 <p>use bundle1 or bundle2 if you do NOT have a byol license</p>
Firewall Vm Name 	VM-Series
Firewall Vm Size 	Standard_D3
* Mgmt Public IP Address Name 	
* Storage Account Name 	
Storage Account Type 	Standard_LRS
* Username 	
Authentication Type 	password
Password 	
Ssh Public Key 	

TERMS AND CONDITIONS

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By clicking "Purchase," I (a) agree to the applicable legal terms associated with the offering; (b) authorize Microsoft to charge or bill my current payment method for the fees associated the offering(s), including applicable taxes, with the same billing frequency as my Azure subscription, until I discontinue use of the offering(s); and (c) agree that, if the deployment involves 3rd party offerings, Microsoft may share my contact information and other details of such deployment with the publisher of that offering.

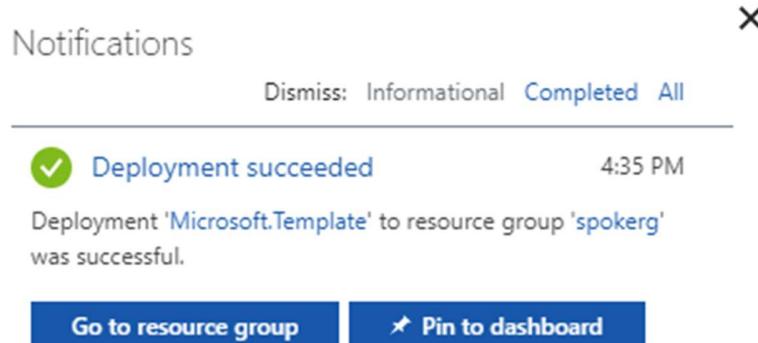
I agree to the terms and conditions stated above

Pin to dashboard

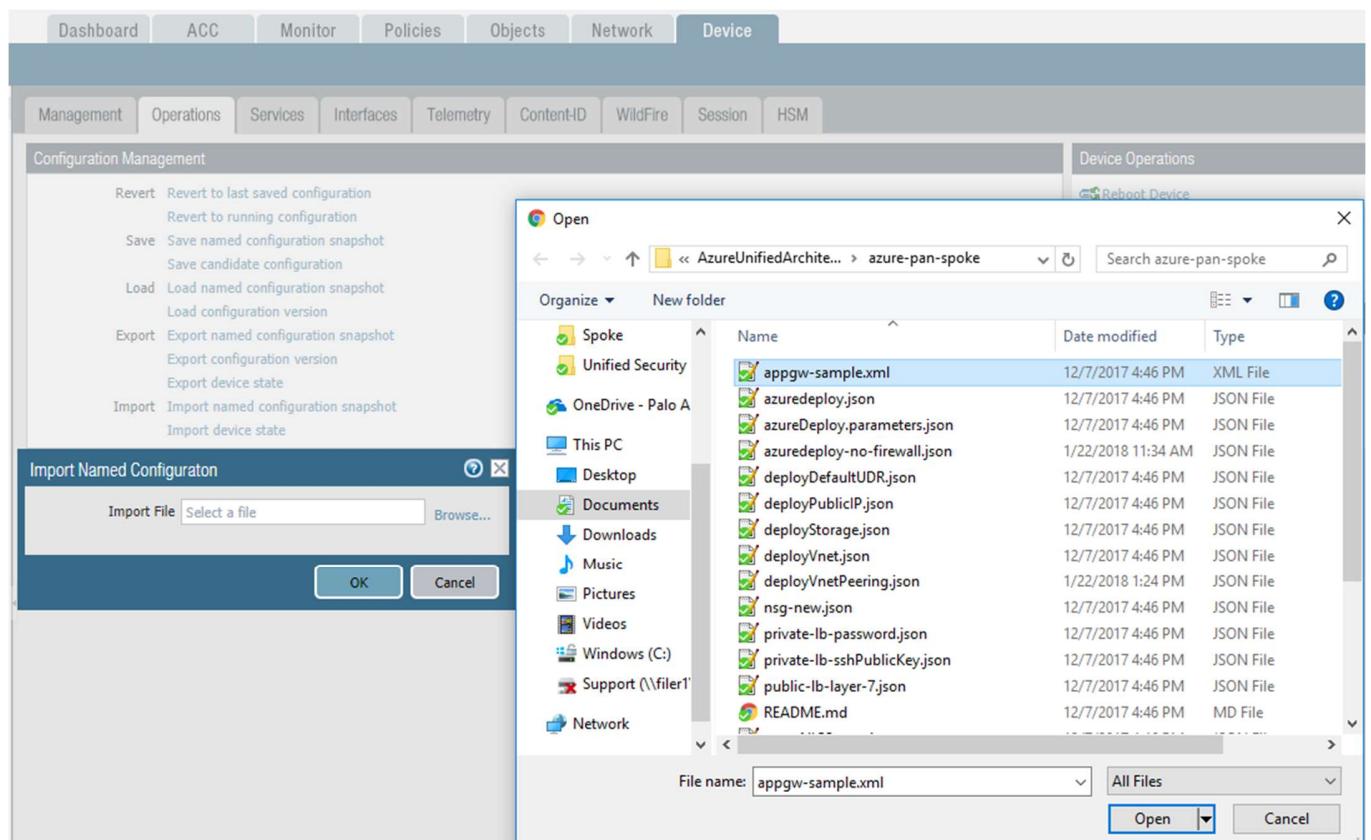
Purchase

Palo Alto Networks Transit VNet with the VM-Series Deployment Guide

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

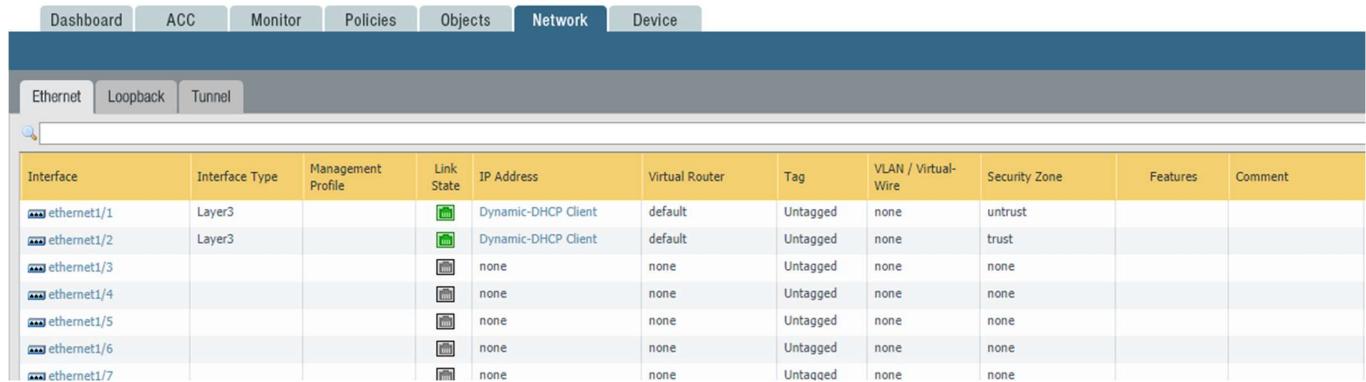


Log into the spoke firewalls using **HTTPS**. Locate the **appgw-sample.xml** configuration snapshot and import this configuration into both firewalls. This is in the Spoke directory that you exported from GitHub.



Palo Alto Networks Transit VNet with the VM-Series Deployment Guide

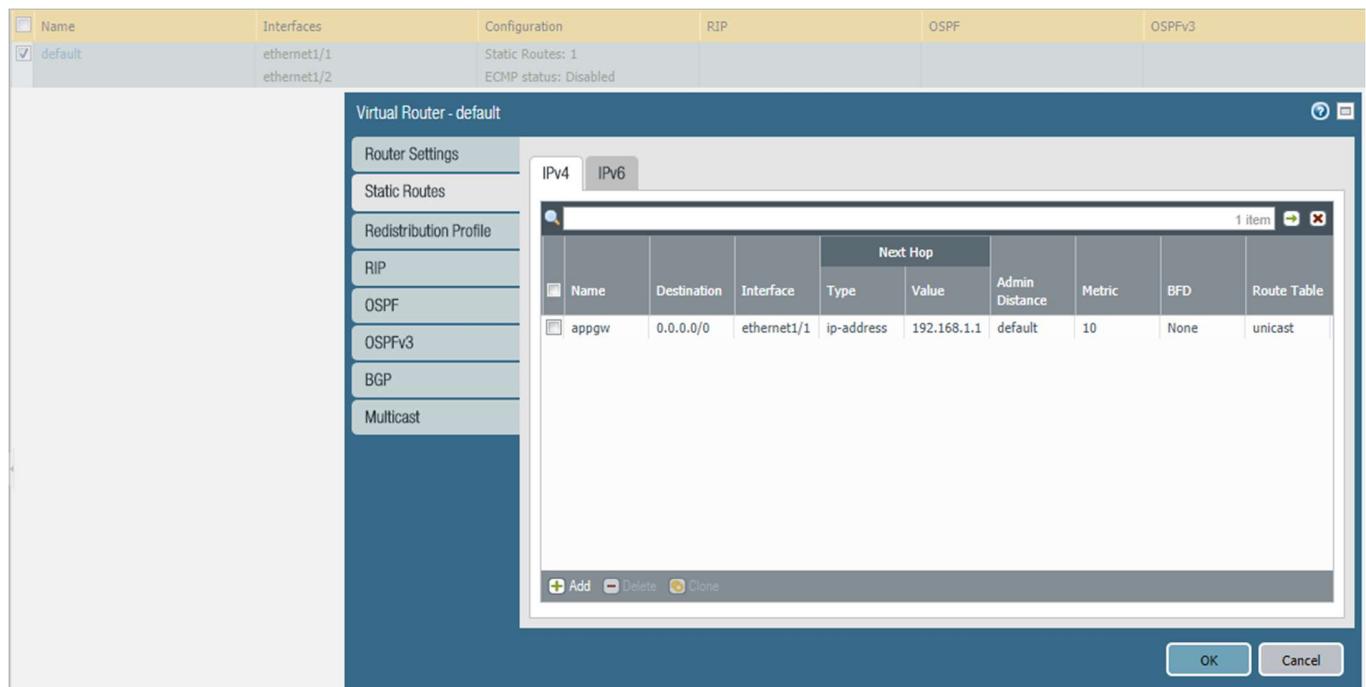
Once you load the configuration and commit the changes. Once you have committed the changes make sure your ethernet1/1 and Ethernet1/2 interfaces now show green



The screenshot shows the Network tab in the Palo Alto Networks Management UI. Under the Ethernet tab, there is a table listing various network interfaces. The columns include Interface, Interface Type, Management Profile, Link State, IP Address, Virtual Router, Tag, VLAN / Virtual-Wire, Security Zone, Features, and Comment. The interfaces listed are ethernet1/1 through ethernet1/7. Most interfaces are shown as 'Dynamic-DHCP Client' with 'Link State' as 'Up'. The security zones for most interfaces are 'untrust' or 'trust', while others are 'none'.

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.



The screenshot shows the configuration of a virtual router named 'default'. The 'Configuration' tab is selected, showing 'Static Routes: 1' and 'ECMP status: Disabled'. A modal dialog titled 'Virtual Router - default' is open, specifically the 'IPv4' tab under 'Router Settings'. It displays a table of static routes. There is one route entry for 'appgw' with the following details:

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 of the dialog are 'OK' and 'Cancel' buttons.

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.

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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	any	any					
1	allow_all	none	universal	any	any	any	any	any	any	any	any	any	X application-d...	Allow	none	none
2	intrazone-default	none	intrazone	any	any	any	any	(intrazone)	any	any	any	any	✓ application-d...	Allow	none	none
3	interzone-default	none	interzone	any	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

	Original Packet								Translated Packet	
	Name	Tags	Source Zone	Destination Zone	Destination Interface	Source Address	Destination Address	Service	Source Translation	Destination Translation
1	ilb	none	any	fw untrust	any	any	firewall-untrust...	any	dynamic-ip-and-port ethernet1/2	address: internal-load-balancer-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.

Virtual networks	
Palo Alto Networks	
 Add	 Columns
 More	
<input type="text" value="Filter by name..."/>	
2 items	
NAME	↑↓
 spoke-vnet	
 vnet	

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Then select **Peerings**

The screenshot shows the 'vnet - Peerings' blade in the Azure portal. The left sidebar contains several navigation links: Overview, Activity log, Access control (IAM), Tags, Diagnose and solve problems, Address space, Connected devices, Subnets, DNS servers, and Peerings. The 'Peerings' link is highlighted with a light blue background.

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.

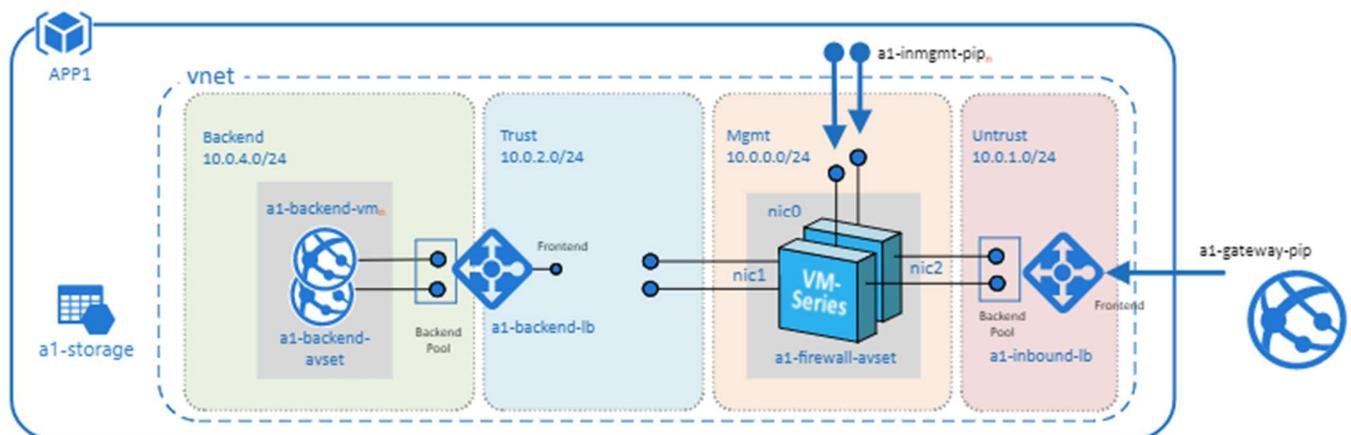
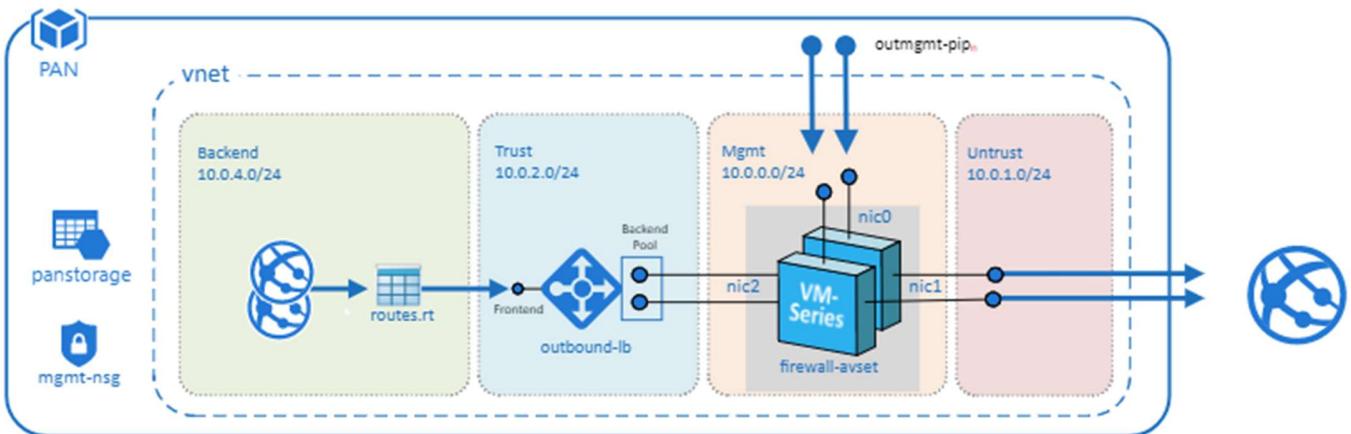
NAME	PEERING STATUS	PEER	GATEWAY TRANSIT	...
vnet-spoke-vnetvnet-peering	Connected	spoke-vnet	Disabled	...

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.

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

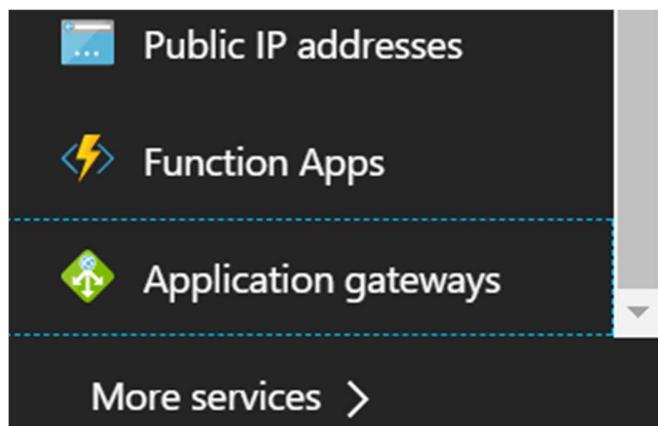
+ Add			
Search routes			
NAME	ADDRESS PREFIX	NEXT HOP	...
defaultRoute	0.0.0.0/0	10.0.2.4	...
mgmt-traffic	.0.0/16	Internet 	...

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

NAME	PUBLIC IP ADDR...	PRIVATE IP ADD...	RESOURCE GROUP
js-waf-appgw1	13.93.203.139	-	js-waf-appgw1
myAppGw	52.165.180.7	-	spokerg
myAppGw-jstestuuid1	104.45.230.21	-	jstestuuid1

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

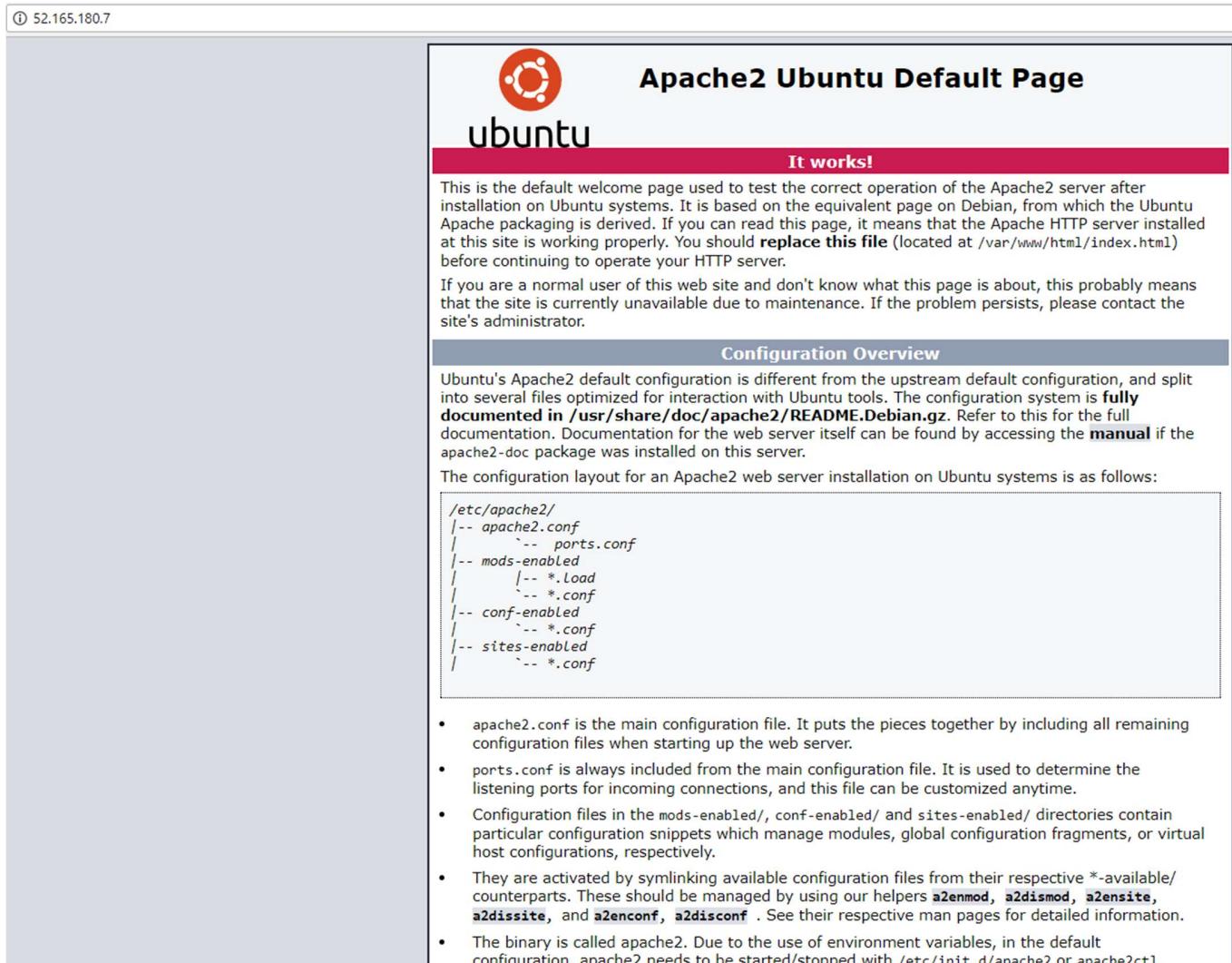
Application gateways
Palo Alto Networks

Add Columns Refresh Assign Tags

Subscriptions: 1 of 2 selected

NAME	PUBLIC IP ADDR...	PRIVATE IP ADD...	RESOURCE GROUP
js-waf-appgw1	13.93.203.139	-	js-waf-appgw1
myAppGw	52.165.180.7	-	spokerg
myAppGw-jstestuuid1	104.45.230.21	-	jstestuuid1

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 at the top left, followed by the word 'ubuntu' in lowercase. A red banner across the middle contains the text 'It works!' in white. Below the banner, a paragraph explains that this is the default welcome page for testing the Apache2 server. It includes instructions to replace the default index file if everything is working correctly. A 'Configuration Overview' section follows, detailing the directory structure for configuration files: /etc/apache2/, which contains apache2.conf (the main config), ports.conf (for ports), mods-enabled (for modules), conf-enabled (for global config fragments), and sites-enabled (for virtual host config). A list of bullet points below this explains the purpose of each file and how they are managed.

52.165.180.7

Apache2 Ubuntu Default Page

It works!

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

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

Configuration Overview

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

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

```
/etc/apache2/
|-- apache2.conf
|   '-- ports.conf
|-- mods-enabled
|   '-- *.Load
|   '-- *.conf
|-- conf-enabled
|   '-- *.conf
|-- sites-enabled
|   '-- *.conf
```

- `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.

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