Agenda: Configure and Manage Azure Virtual Networks

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- Understanding Network Resources
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    - Create a Subnet
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    - Create Network Interface Card with public, and private IP addresses
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- Setup Network Security Group
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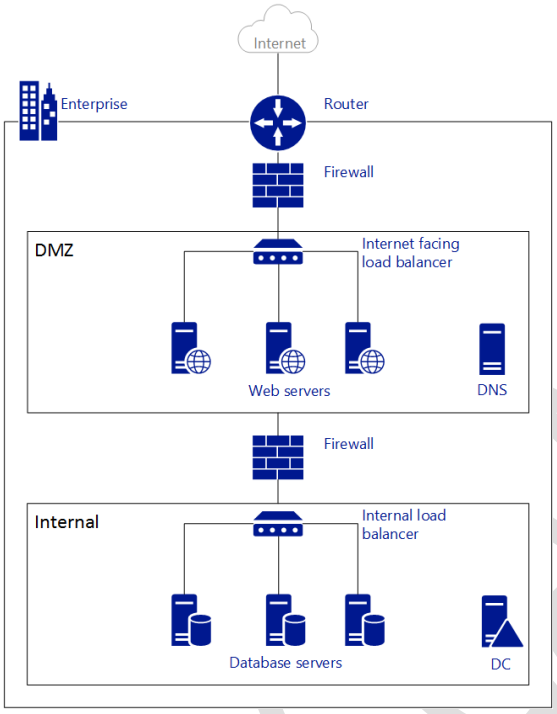
Overview of Azure Networking

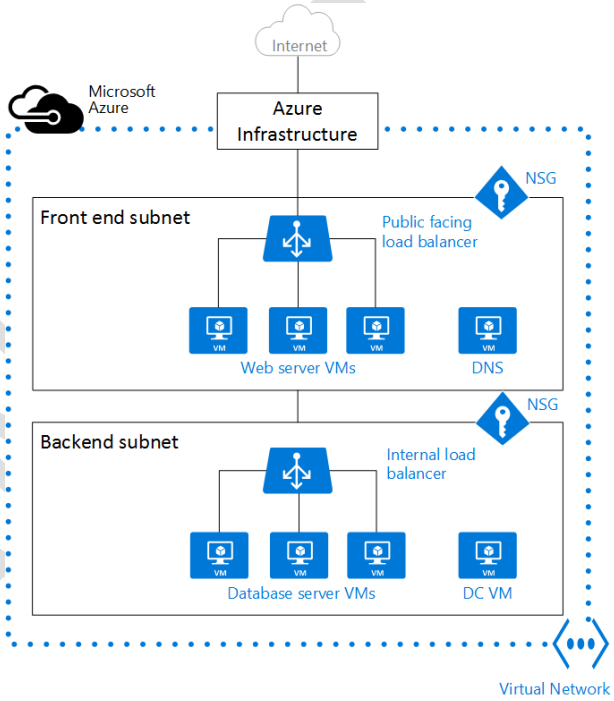
- An Azure virtual network (VNet) is a representation of your own network in the cloud.

- It is **a logical isolation** of the Azure cloud dedicated to your subscription. You can fully control the IP address blocks, DNS settings, security policies, and route tables within this network.
- You can also further segment your VNet into **subnets** and launch Azure virtual machines (VMs).
- You can connect the virtual network to your on-premises network using one of the connectivity options available in Azure. In essence, you can expand your network to Azure, with complete control on IP address blocks with the benefit of enterprise scale Azure provides.

Simplified on-premises network.



Same network can be hosted in Azure



*In computer **networks**, a **DMZ** (**demilitarized zone**) is a physical or logical **sub-network** that separates an internal local area **network** (LAN) from other untrusted **networks**, usually the Internet.

Notice how the Azure infrastructure takes on the role of the router, allowing access from your VNet to the public Internet without the need of any configuration. Firewalls can be substituted by Network Security Groups (NSGs) applied to each individual subnet. And physical load balancers are substituted by internet facing and internal load balancers in Azure.

Azure VNet Pricing:

- There is **no extra cost** for using Virtual Networks in Azure.
- The compute instances launched within the Vnet will be charged the standard rates as described in Azure VM Pricing.
- The VPN Gateways and Public IP Addresses used in the VNet will also be charged standard rates.

Virtual Network Benefits

- **Isolation**. VNets are completely isolated from one another. That allows you to create disjoint networks for development, testing, and production that use the same CIDR address blocks.
- **Access to the public Internet**. All IaaS VMs and PaaS role instances in a VNet can access the public Internet by default. You can control access by using Network Security Groups (NSGs).
- **Security**. Traffic entering and exiting the virtual machines and PaaS role instances in a VNet can be controlled using Network Security groups.
- **Access to VMs within the VNet**. PaaS role instances and IaaS VMs can be launched in the same virtual network and they can connect to each other using private IP addresses even if they are in different subnets without the need to configure a gateway or use public IP addresses.
- **Name resolution**. Azure provides internal name resolution for IaaS VMs and PaaS role instances deployed in your VNet. You can also deploy your own DNS servers and configure the VNet to use them.
- **Connectivity**. VNets can be connected to each other, and even to your on-premises datacenter, by using a site-to-site VPN connection, or ExpressRoute connection.

Note: The most important thing about Windows Azure virtual networks is that you cannot add an existing virtual machine to a newly created virtual network. It is important that if you want to leverage virtual networking in Windows Azure that you must create the virtual networks **BEFORE** creating your virtual machines! Don't miss this important step. You'll be disappointed if you've spent a lot of time setting up a virtual machine and later find that you can't move it to a virtual network

Understanding Network Resources

- **IP addresses**: There are two types of IP addresses assigned to resources in Azure: *public* and *private*.
    a. **Public IP Addresses** allow Azure resources to communicate with Internet and other Azure public-facing services like Azure Redis Cache.
    b. **Private IP Addresses** allows communication between resources in a virtual network, along with those connected through a VPN, without using an Internet-routable IP addresses.

Preferred IP Series for Intranets:

Small Network1: 192.168.0.X – for 2^8 Systems – IP Address Range = 192.168.0.0/24 (Only last byte changes)

Small Network2: 192.168.1.X –for 2^8 Systems – IP Address Range = 192.168.1.0/24 (Only last byte changes)

Large Network: 172.16.X.X – for 2^{16} Systems - IP Address Range = 172.16.0.0/16 (last 2 bytes change)

Very Large Network: 10.X.X.X – for 2^{24} Systems – IP Address Range = 10.0.0.0/8 (last 3 bytes change)

Classless Inter-Domain Routing (**CIDR) notation** is a compact representation of an IP address and its associated routing prefix. The **notation** is constructed from an IP address, a slash ('/') character, and a decimal number. The number is the count of leading 1 bits in the routing mask, traditionally called the network mask.

Public IP Addresses

- There are two methods in which an IP address is allocated to a *public* IP resource - ***dynamic*** or ***static*.**
  - In the **dynamic** allocation method the IP address is **not** allocated at the time of its creation. Instead, the public IP address is allocated when you start (or create) the associated resource (like a VM or load balancer). The IP address is released when you stop (or delete) the resource. This means the IP address can change.
  - In the **static** allocation method the IP address for the associated resource does not change. In this case an IP address is assigned immediately. It is released only when you delete the resource or change its allocation method to *dynamic*.
- Public IP addresses allow Azure resources to communicate with Internet and Azure public-facing services such as Azure Redis Cache, Azure Event Hubs, SQL databases and Azure storage.
- In Azure Resource Manager, a public IP address is a resource that has its own properties. You can associate a public IP address resource with any of the following resources:
  - Internet-facing Virtual machines (VM)
  - Internet-facing load balancers
  - VPN gateways
  - Application gateways
- The first 5 “static” public IP addresses in a region are free. This is applicable irrespective of the type of resource (VM or Load-balancer) to which the IP address is associated. All others are charged at $0.004/hr.

Private IP Addresses

1. IP address is allocated from the address range of the subnet to which the resource is attached.
2. The default allocation method is dynamic, where the IP address is automatically allocated from the resource's subnet (using DHCP). This IP address can change when you stop and start the resource.
3. You can set the allocation method to static to ensure the IP address remains the same. In this case, you also need to provide a valid IP address that is part of the resource's subnet.
4. Private IP addresses allow Azure resources to communicate with other resources in a virtual network or an on-premises network through a VPN gateway or ExpressRoute circuit, without using an Internet-reachable IP address.
5. In the Azure Resource Manager deployment model, a private IP address is associated to the following types of Azure resources:
   - VMs

- Internal load balancers (ILBs)
- Application gateways

- **Subnets**: Subnet is a **range of IP addresses** in the VNet, you can divide a VNet into multiple subnets for organization and security. VMs and PaaS role instances deployed to subnets (same or different) within a VNet can communicate with each other without any extra configuration. You can also configure route tables and NSGs to a subnet.

  Based on number of system in a network, Subnet Mask is set.

  255.255.255.0 - 2^8 Systems

  255.255.0.0 – 2^{16} Systems

  255.0.0.0 – 2^{24} Systems

- **Network Interface Card (NIC):** VMs communicate with other VMs and other resources on the network by using virtual network interface card (NIC). Virtual NICs configure VMs with private and optional public IP address. VMs can have more than one NIC for different network configurations.

  Note: VMs can have more than one NIC adapter that links the VM with the virtual network. The number of NICs you can attach to a VM depends on its size. For example, a VM that is based on a D2 size can have 2 NICs, and a D4-based VM can have a maximum of 8 NICs. Multiple NICs configuration is common for virtual appliances that provide additional control of traffic in virtual networks.

- **Network Security Group** (NSG): You can create NSGs to control inbound and outbound access to network interfaces (NICs), VMs, and subnets. Each NSG contains one or more rules specifying whether or not traffic is **approved or denied** based on **source IP address, source port, destination IP address, and destination port.**

  Some important things to keep in mind while implementing network security groups include:

  - By default you can create **100 NSGs** per region per subscription. You can raise this limit to **400** by contacting Azure support.
  - You can apply only one NSG to a VNet, subnet, or NIC.
  - By default, you can have up to **200 rules** in a single NSG. You can raise this limit to **500** by contacting Azure support.
  - You can apply an NSG to multiple resources.

- **Azure Load Balancers**: The Azure Load Balancer delivers high availability and network performance to your applications. It is a **Layer 4 (TCP, UDP) load balancer** that distributes incoming traffic among healthy service instances in cloud services or virtual machines defined in a load-balanced set.

- **Application Gateways:** Azure Application Gateway is a **layer-7 load balancer**. It provides failover, performance-routing HTTP requests between different servers, whether they are on the cloud or on-premises. Application Gateway provides many Application Delivery Controller (ADC) features including HTTP load balancing, cookie-based session affinity, Secure Sockets Layer (SSL) offload, custom health probes, support for multi-site, and many others.

- **Traffic Manager:** Microsoft Azure Traffic Manager allows you to control the distribution of user traffic for service endpoints in different datacenters. Service endpoints supported by Traffic Manager include Azure VMs, Web Apps, and cloud services. You can also use Traffic Manager with external, non-Azure endpoints. Traffic Manager uses the Domain Name System (DNS) to direct client requests to the most appropriate endpoint.

- **VPN Gateways:** Azure VPN Gateway is used to connect an Azure virtual network (VNet) to other Azure VNets or to an on-premises network. You need to assign a public IP address to its IP configuration to enable it to communicate with the remote network. Currently, you can only assign a ***dynamic* public IP** address to a VPN gateway.

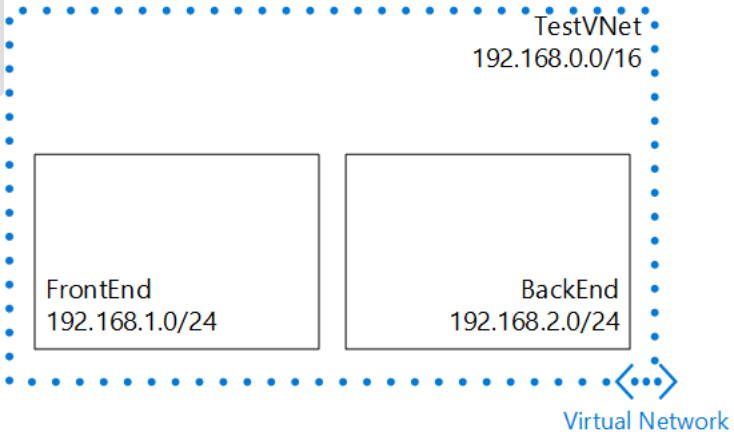
- **Azure DNS:** The Domain Name System (DNS) enables clients to resolve user-friendly fully qualified domain names (FQDNs), such as www.adatum.com, to IP addresses**.** Azure Domain Name System (DNS) allows you to host your domains with your Azure apps. By hosting your domains in Azure, you can manage your DNS records by using your existing Azure subscription.

Create a Virtual Network (VNet) using the Azure portal

In this scenario we will create a VNet named **TestVNet** with a reserved CIDR block of **192.168.0.0/16**.

Your VNet will contain the following **subnets**:

- **FrontEnd**, using **192.168.1.0/24** as its CIDR block.
- **BackEnd**, using **192.168.2.0/24** as its CIDR block.



1. Click All Services → Virtual network → **+Add** → Select a deployment model = Resource Manager → click Create
2. Name=Test-nvet, Address Space=198.162.0.0/16, Subnet name="Frontend-subnet", Subnet Address Range=192.168.1.0/24, Select Resource Group → Create
3. Wait for the VNet to be created, → **Virtual network** blade, click **All settings** → **Subnets** → **Add** a new Subnet. (Name=Backend-subnet, Address space=192.168.2.0/24, Leave NSG and Route table=None → OK

Create Network Interface Card:

4. **Create a Public IP Address**: Name=WebVM1-ip, Select Resource Group, AllocationMethod=Static, DomainNameLabel=WebVM1-ip

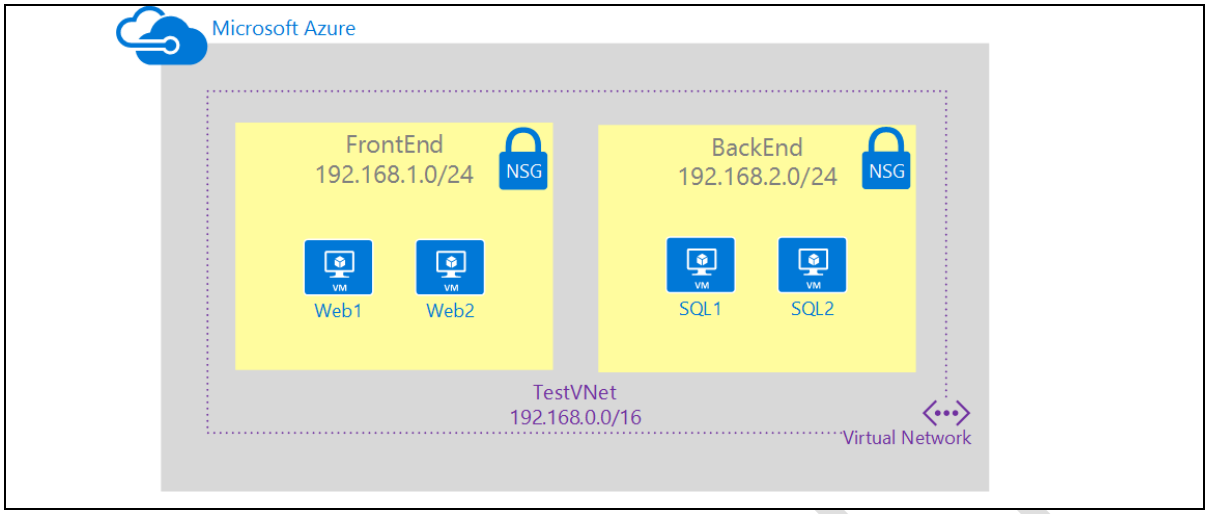
5. More Services → Network Interface Card → Add → Name=WebVM1-nic, Virtual Network=Test-vnet, Subnet=Frontend, Private IP Address assignment: Static (198.168.1.100), Network Security Group=None.
6. **Assigning Public IP to NIC**: Select WebVM1-nic → Settings → IP addresses → Public IP=Enabled, Select Static IP created before → Save.

Network Security Group

NSGs are simple, stateful packet inspection devices that use the 5-tuple (the source IP, source port, destination IP, destination port, and layer 4 protocol) approach to create allow/deny rules for network traffic. You allow or deny traffic to and from a single IP address, to and from multiple IP addresses, or to and from entire subnets.

In this scenario you will create an NSG for each subnet in the **TestVNet** virtual network, as described below:

- **NSG-FrontEnd**. The front end NSG will be applied to the *FrontEnd* subnet, and contain two rules:
  - **rdp-allow**. This rule will allow RDP traffic to the *FrontEnd* subnet.
  - **web-allow**. This rule will allow HTTP traffic to the *FrontEnd* subnet.
- **NSG-BackEnd**. The back end NSG will be applied to the *BackEnd* subnet, and contain two rules:
  - **sql-allow**. This rule allows SQL traffic only from the *FrontEnd* subnet.
  - **Rdb**-allow: This rule will allow RDP traffic to the *BackEnd* subnet
  - **web-deny**. This rule **denies all internet bound** traffic **from** the *BackEnd* subnet.



7. **Create NSG for Frontend:** Browse → Network Security Groups → Add → Name=**Frontend-nsg** → Create
   a. Select Frontend-nsg → Settings →
      i. Inbound security rules → Add, Name=**web-allow**, priority, Priority=100, Source=Any, Source port range=*, Protocol=**TCP**, Destination=Any, Destination port range=80, Action=Allow → OK
      ii. Inbound security rules → Add, Name=**rdp-allow**, priority, Priority=100, Source=Any, Source port range=*, Protocol=**TCP**, Destination=Any, Destination port range=3389, Action=Allow → OK
   b. **Associate the NSG to the FrontEnd subnet**
      i. Select Test-vnet → Settings → Subnets → Frontend-subnet → Network security group → Select Frontend-nsg → Save
8. **Create NSG for Backend:** Browse → Network Security Groups → Add → Name=Backend-nsg → Create
   a. Select Backend-nsg → Settings →
      i. Inbound security rules → Add, Name=**sql-allow**, priority, Priority=100, Source=**CIDR block**, **Source IP address range=192.168.1.0/24,** Source port range=*, Protocol=**TCP**, Destination=Any, Destination port range=**1433**, Action=Allow → OK
      ii. Inbound security rules → Add, Name=**rdp-allow**, priority, Priority=100, Source=Any, Source port range=*, Protocol=**TCP**, Destination=Any, Destination port range=3389, Action=Allow → OK
      iii. **Outbound** security rules → Add, Name=**web-deny**, priority, Priority=100, Destination=**Tag**, destination Tag=**Internet**, Destination port range=80, Source=**Any**, Protocol=**Any**, Source port range=*, Action=**Deny** → OK
   b. Associate the NSG to the BackEnd subnet
      i. Select Test-vnet → Settings → Subnets → Backend-subnet → Network security group → Select Backend-nsg → Save

Creating a Virtual Machine

9. Azure portal → On the Hub menu, click New → Compute → Windows Server 2012 R2 Datacenter.

Note: To find additional images, click Marketplace and then search or filter for available items.

10. On the Windows Server 2012 R2 Datacenter page, under Select a deployment model = Resource Manager → Create.
11. Create virtual machine blade →
    a. Basics → provide values for Name, Username and Password, Resource Group → OK
    b. Size → Select an appropriate virtual machine size for your needs. Note that Azure recommends certain sizes automatically depending on the image you choose.
    c. Settings to see storage and networking settings for the new virtual machine.
        i. NSG = None
        ii. AvailablitySet = WebServer-availablitySet
    d. Click Summary to review your configuration choices.
12. Click Create

Create the following two VM

DemoVM1

DemoVM1-nic (name provided by Azure)

DemoVM1-publicIP

DemoVM2

DemoVM2-nic (name provided by Azure)

DemoVM2-publicIP

For both VM, NSG = None

RDP into both the machines and install IIS Web Server in both.

Summary:

Demo-VNet
- Frontend-subnet
  - Frontend-nsg
    - Allowed HTTP and RDP
  - Web1-vm
    - NO NSG
    - Remote Login and installed IIS
    - edit wwwroot\iisstart.png - Added ONE
  - Web2-vm

NO NSG

Remote Login and installed IIS

edit wwwroot\iisstart.png - Added TWO

Web1-ip

DNS Name

Backend-sub

Backend-nsg

Allowed RDP Inbound

Denied HTTP OutBound

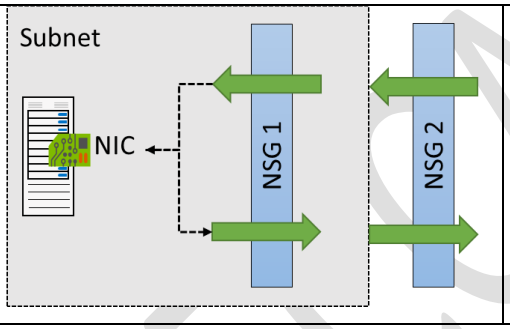
Accessed

Web1 http://<ip> or http://<dnsname>

Web2 http://<ip> or http://<dnsname>

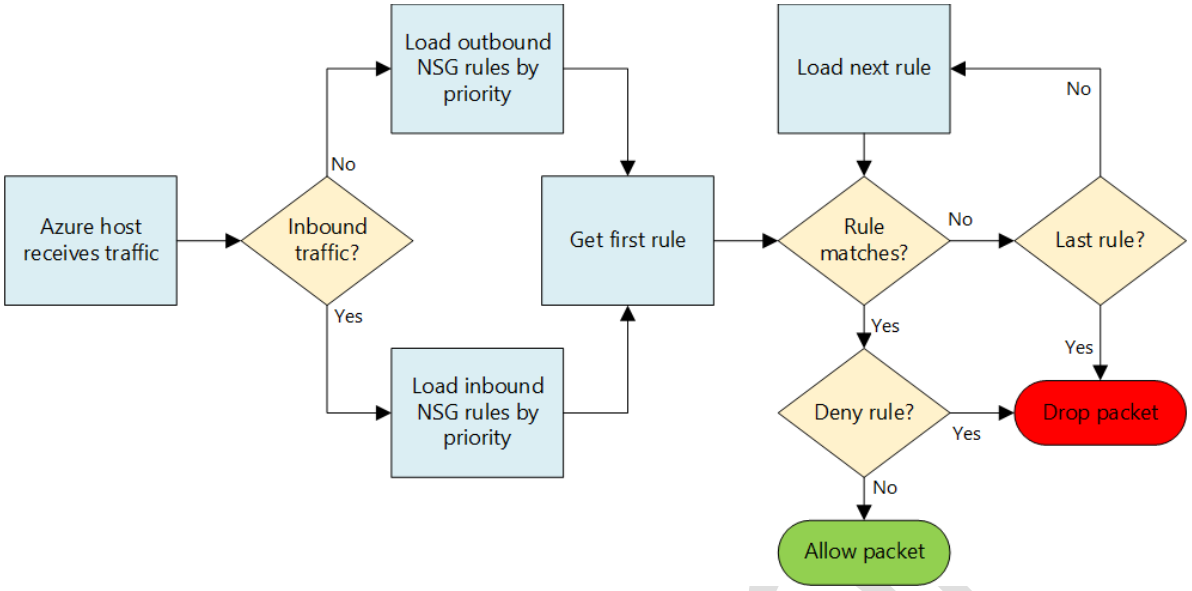
NSG: Evaluate effective security rules

Be very careful when you want to apply NSG to both VM (NIC) and subnet level at the same time. NSGs are evaluated independently, and an "allow" rule must exist at **both levels** otherwise traffic will not be admitted.



If there was incoming traffic on port 80, you would need to have the NSG at subnet level ALLOW port 80, and you would also need another NSG with ALLOW rule on port 80 at the NIC level. For incoming traffic, the NSG set at the subnet level is evaluated first, then the NSG set at the NIC level is evaluated. For outgoing traffic, it is the converse

The picture below should even clarify this concept more: you can see how rules are evaluated for network packets, once again remember that you need to **evaluate this diagram two times**: once for subnet level NSG rules, and once for NIC level NSG rules.



To see the Effective Rules:

Select the VM → Settings → Networking → Click on **Effective security rules**

Now you get an overview which NSGs are associated with the VM's NIC and which rules are applied to it.

For an offline analysis there is a download option, that generates a CSV file of the output.

Service Endpoints

Virtual network service endpoints enable you to limit network access to Azure service resources. Access is limited to just the virtual network subnets and IP addresses you specify.

Currently, Azure supports service endpoints to these services: Cosmos DB, Event Hub, Key Vault, SQL, and Storage and few more…

Endpoints allow you to secure your critical Azure service resources to your virtual networks.

Walkthrough:

1. Create a virtual network with one subnet with disabled Service EndPoint
2. Add another subnet and enable a service endpoint. Eg: Storage Service
3. Create an Azure resource (eg: Storage Service) and allow network access to it from only a subnet.
4. Deploy a virtual machine (VM) to each subnet.
5. Confirm access to a resource from an allowed subnet. (eg: Map a Virtual drive for the File Share)
6. Confirm access is denied to a resource from another subnet and the internet.

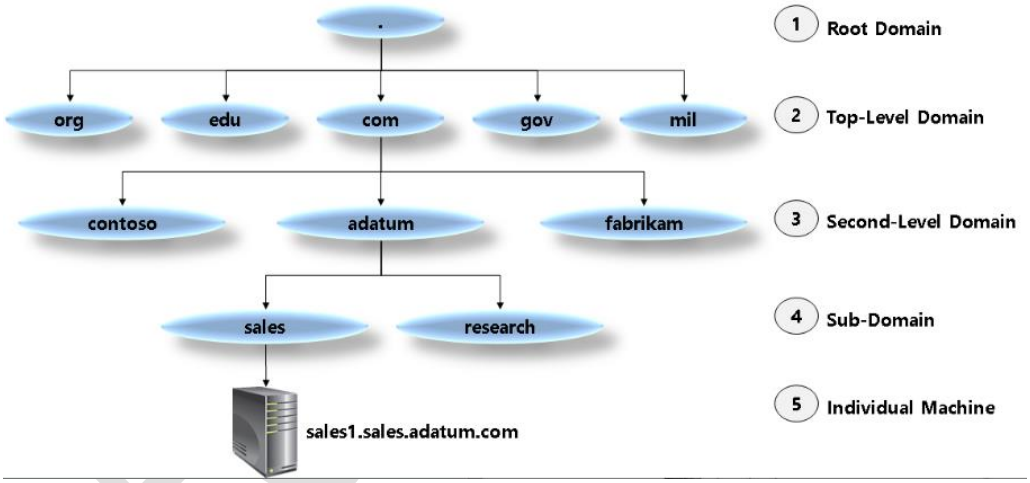
Note: Azure Storage File Service can be used for this demo.

Azure DNS

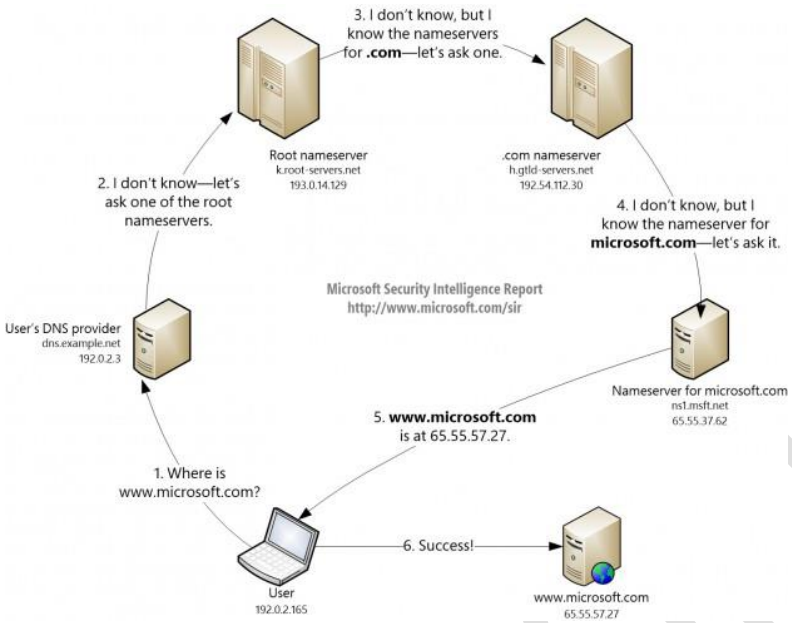
- The Domain Name System, or DNS, is responsible for translating (or resolving) a website or service name to its IP address.
- Azure DNS is a hosting service for DNS domains, providing name resolution using Microsoft Azure infrastructure.
- Can be managed via the Azure portal, Azure PowerShell cmdlets, and the cross-platform Azure CLI. Applications requiring automatic DNS management can integrate with the service via the REST API and SDKs.
- When you add a new DNS record, the Azure DNS name servers are updated in a few seconds so you don't have to wait long before that DNS record can be used.
- Azure DNS does not currently support purchasing of domain names.

DNS Domains:

The DNS is a hierarchy of domains. The hierarchy starts from the 'root' domain, whose name is simply '.'. Below this come top-level domains, such as 'com', 'net', 'org', 'uk' or 'jp'. Below these are second-level domains, such as 'org.uk' or 'co.jp'. The domains in the DNS hierarchy are globally distributed, hosted by DNS name servers around the world.



DNS Resolution: To answer queries, it uses aspecial type of DNS record called a Name Server (NS)record. For example, the root zone contains NS records for 'com'and shows the name servers for the 'com' zone. In turn,the 'com' zone contains NS records for 'contoso.com', whichshows the name servers for the 'contoso.com' zone. Settingup the NS records is called delegating the domain.



How DNS Server Works

In browser http://www.bestazuretraining.com

1. Browser will send request to DNS Server as configured in your machine for finding IP of www.bestazuretraining.com
2. DNS if has IP - It immediately returns
3. DNS does'nt have IP - It will send the request to ROOT Name Server
4. Root Name Server will query -> .com Name Server
5. .com Name Server will sent the request Azure name server
6. In Azure Name Server it will search for the required Recordset and return the value...
7. If IP is returned browser will directly send the request to target machine...
8. If Alias (CName) is returned then it again starts from Step 2...

DNS Zone:

A DNS zone is used to host the DNS records for a particular domain. In order to start hosting your domain, you need to create a DNS zone. Any DNS record created for a particular domain will be inside a DNS zone for the domain.

For example, the domain "contoso.com" may contain a number of DNS records, such as "mail.contoso.com" (for a mail server) and "www.contoso.com" (for a web site).

About DNS Zone names

2. The name of the zone must be unique within the resource group, and the zone must not exist already. Otherwise, the operation will fail.

3. The same zone name can be re-used in a different resource group or a different Azure subscription.
4. Where multiple zones share the same name, each instance will be assigned different name server addresses.
5. **Only one set of addresses can be configured with the domain name registrar.**

Steps to Create a DNS Zone and Map Name to IP Address:

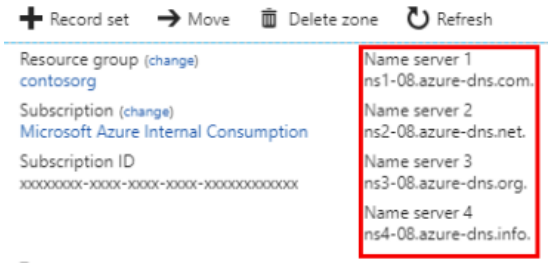
1. Buy a Domain Name from a Registrar (eg: godaddy.com is registrar)

2. Azure Portal → New → Networking → DNS zone

3. Name = deccansoft.net, Provide other details → Create

4. Goto Registrar Website → Login

5. DNS Delegation: Map domain Name Server to NS records for the DNS Zone created



6. Select the DNS Zone → + Record set → Name=www, Type="A", TTL=1, IP Address=<Public IP of VM Created> → OK

DNS Record Type:

Record Type	Full Name	Function
A (IPv4) AAAA (IPv6)	Address	Maps a host name such as mail.adatum.com to an IP address, such as 131.107.10.10.
CNAME	Canonical name	Points one host record, such as adatum.ftp.adatum.com, to another host record, such as mail.lucernepublishing.com, or even another host record in another domain, such as www.contoso.com.
MX	Mail exchange	Points to the host that will receive mail for that domain. MX records must point to an A record, not to a CNAME record.
NS	Name server	Delegates a DNS zone to the specified authoritative name server.
SOA	Start of Authority	Defines the authoritative record for the zone.
SRV	Service	Locates hosts that are providing specific services, such as the Session Initiation Protocol (SIP) endpoint.
TXT	Text	Records a human-readable text field in DNS.

To Test the name resolution

- **Ipconfig** /all
- **ping** <host name>
- **nslookup** <host name> <name server name>
- **nslookup** www.bestazuretraining.com ns1-01.azure-dns.com

Private DNS Zones

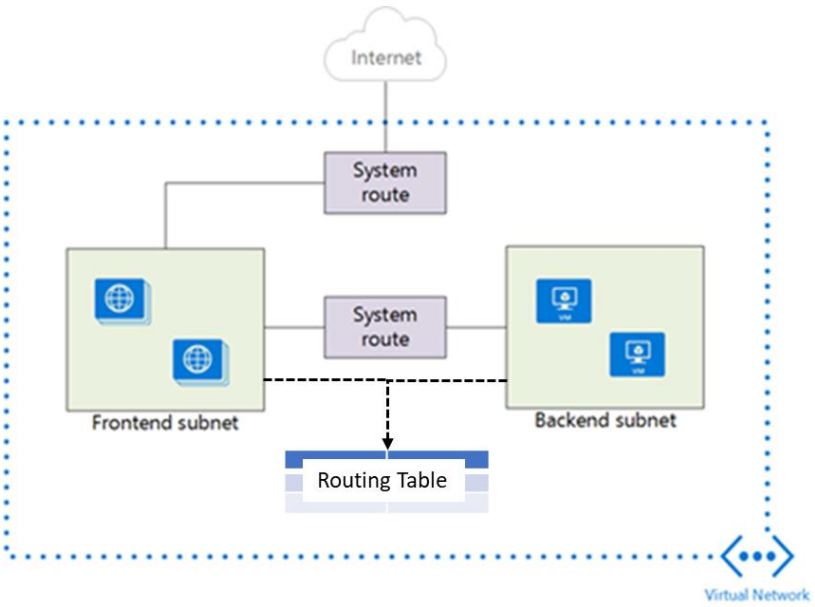
https://docs.microsoft.com/en-us/azure/dns/private-dns-getstarted-cli

Network Route Table

- When you add virtual machines (VMs) to a virtual network (VNet) in Azure, you will notice that the VMs are able to communicate with each other over the network, automatically. You do not need to specify a gateway, even though the VMs are in different subnets. The same is true for communication from the VMs to the public Internet, and even to your on-premises network when a hybrid connection from Azure to your own datacenter is present.
- This flow of communication is possible because Azure uses a series of **system routes** to define how IP traffic flows.

System routes control the flow of communication in the following scenarios:

- From within the same subnet.
- From a subnet to another within a VNet.
- From VMs to the Internet.
- From a VNet to another VNet through a VPN gateway.
- From a VNet to another VNet through VNet Peering (Service Chaining).
- From a VNet to your on-premises network through a VPN gateway.



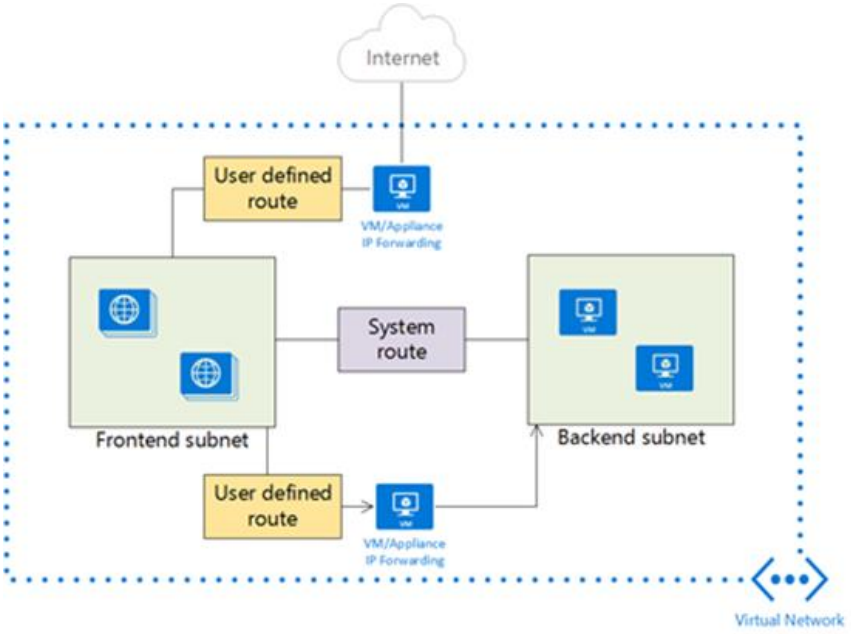
Information about the **system routes** is recorded in a **route table**. A route table contains a set of **rules**, called **routes**, that specifies how packets should be routed in a virtual network. Route tables are **associated to subnet**s, and each packet leaving a subnet is handled based on the associated route table. Packets are matched to routes using the destination. The destination can be an **IP address, a virtual network gateway, a virtual appliance, or the internet**. If a matching route can't be found, then the packet is **dropped.**

User Defined Routes

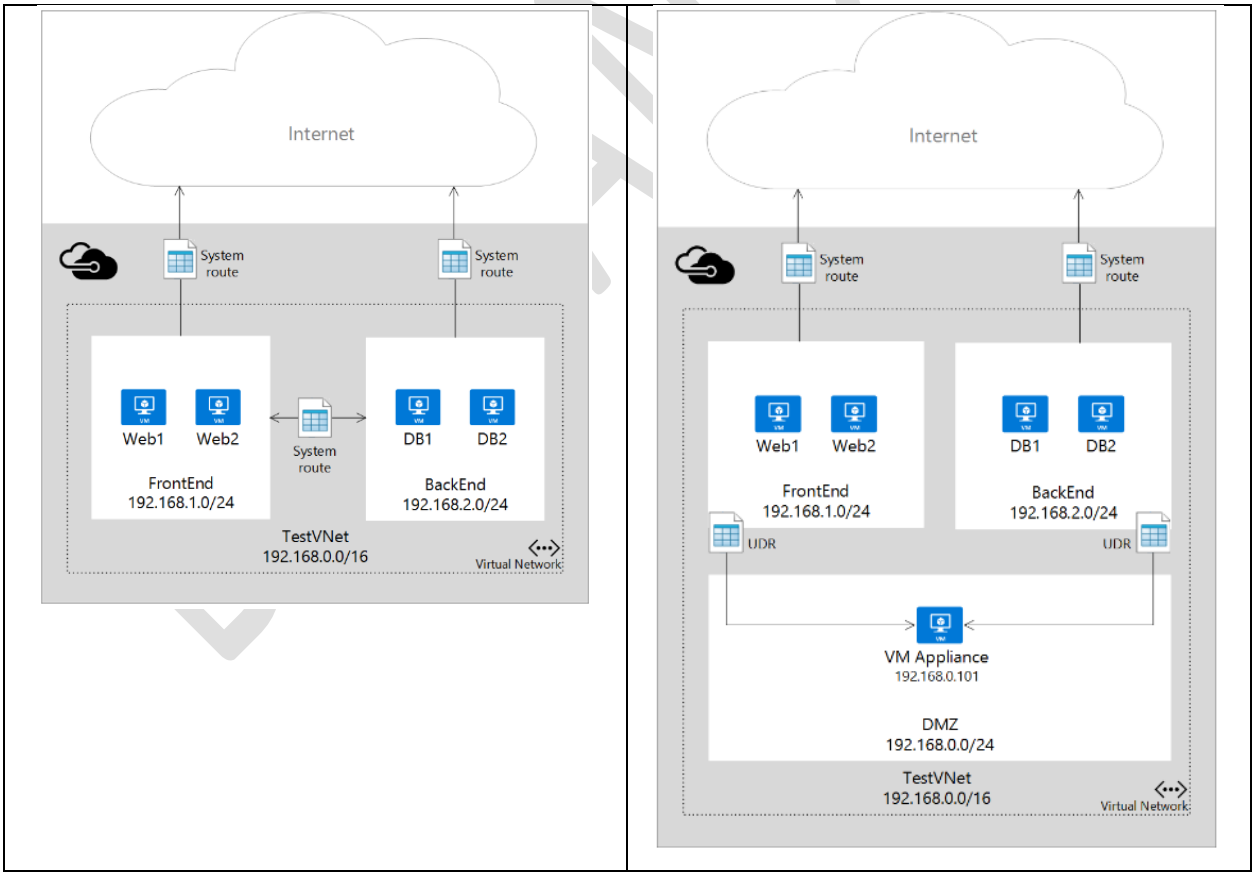
For most environments you will only need the system routes already defined by Azure.

However, you may need to create a route table and add one or more routes in specific cases, such as:

- Force tunneling to the Internet via your on-premises network.
- Use of virtual appliances in your Azure environment.



Each route table can be associated to multiple subnets, but a subnet can only be associated to a single route table. There are no additional charges for creating route tables in Microsoft Azure.



- User defined routes are only applied to **traffic leaving a subnet**. You cannot create routes to specify how traffic comes into a subnet from the Internet, for instance. Also, the appliance you are forwarding traffic to

cannot be in the same subnet where the traffic originates. **Always create a separate subnet for your appliances**.

- NVAs are VMs that help with network functions like routing and firewall optimization. Some of the cases where virtual appliances can be used include:
    - Monitoring traffic with an intrusion detection system (IDS).
    - Controlling traffic with a firewall.
- This **virtual appliance VM** must be able to receive incoming traffic that is not addressed to itself. To allow a VM to receive traffic addressed to other destinations, you must **enable IP Forwarding** for the VM. This is an Azure setting, not a setting in the guest operating system.
- You can have multiple route tables, and the same route table can be associated to one or more subnets. And each subnet can only be associated to a single route table.

NOTE: An **intrusion detection system** (IDS) is a device or software application that monitors a network or systems for **malicious activity or policy violations**. Any malicious activity or violation is typically reported either to an administrator or collected centrally using a security information and event management (SIEM) system. A SIEM system combines outputs from multiple sources, and uses alarm filtering techniques to distinguish malicious activity from false alarms.
The most common classifications are **network intrusion detection systems** (**NIDS**) and **host-based intrusion detection systems** (HIDS).

Network security capabilities of virtual network security appliances include:

- Firewalling
- Intrusion detection/intrusion prevention
- Vulnerability management
- Application control
- Network-based anomaly detection
- Web filtering
- Antivirus
- Botnet protection

To find available Azure virtual network security appliances, go to the Azure Marketplace and search for “security” and “network security.”

Create User Defined Routes (UDR) :

1. Create a **New** Subnet with Address Prefix 192.168.3.0/24.
2. Here the VM Appliance Virtual Machine should be created with private IP address **192.168.3.4**.

UDR for Frontend Subnet when target is any VM in backend subnet

3. Create UDR: More Services → Route table → + Add
4. Set Name=Frontend-udr-table . . . → Create
5. Virtual network gateway route propagation = Enabled (default)

Border Gateway Protocol (**BGP**): An on-premises network gateway can exchange routes with an Azure virtual network gateway using the BGP. Routes are automatically added to the route table of all subnets with BGP propagation enabled.

6. Select Route table → Routes → + Add
7. Set Name=FrontendSubnet-route, [Destination] Address prefix=192.168.2.0/24 (Range of Backend Subnet), Next hop type=Virtual appliance, Next hop address = **192.168.3.4** (Private IP of VM Appliance)

Routing Algorithms: **a) Longest prefix match algorithm** For example, if the destination address is 10.0.0.5 and there are two routes: One route specifies the 10.0.0.0/24 address prefix, while the other route specifies the 10.0.0.0/16 address prefix. In this case, Azure selects a route using the longest prefix match algorithm, which is the 10.0.0.0/24 route. b) If multiple routes contain the **same address prefix**, Azure selects the route type, based on the following priority: 1. User-defined route 2. BGP route 3. System route c) A route with the **0.0.0.0/0** address prefix instructs Azure how to route traffic destined for an IP address that is not within the address prefix of any other route in a subnet's route table.

8. Select Frontend-udr-table → Subnets → +Associate → Select Frontend-subnet

For the VM in New Subnet:

9. Enable IP Forwarding for NIC of FW1 VM.
    1. Goto Virtual machine → Networking → Click on Network Interface Card (eg: **web3-vm126)**
    2. IP Configuration → **IP Forwarding = Enable**

10. In source and target VM (with PrivateIP 192.168.2.4), Enable Internet Control Message Protocol (ICPM) which the Windows Firewall denies by default.
    1. RDP to **BOTH** VM (In Frontend subnet and Backend subnet) → PowerShell
    2. Execute the command on both VM's

       `New-NetFirewallRule –DisplayName “Allow ICMPv4-In” –Protocol ICMPv4`

11. Turn on IP forwarding within **Virtual Appliance VM** Operating System.

1. RDP to Virtual Appliance VM → PowerShell
2. Execute the following command

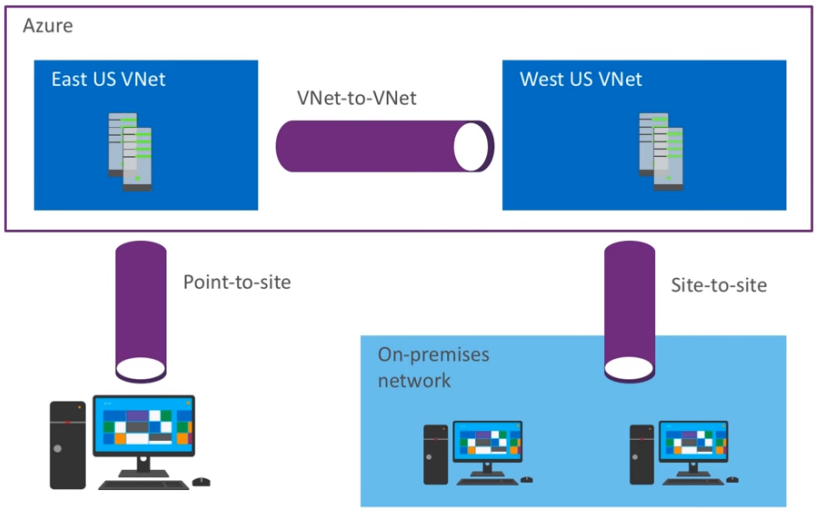
   ```
   Set-ItemProperty -Path HKLM:\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters -Name IpEnableRouter -Value 1
   ```
3. Restart the Virtual Appliance VM

12. Test the routing of network traffic
    1. RDP to Source VM (Frontend subnet) → PowerShell
    2. Execute the following command

       tracert <Target VM Name>
    3. Note that the first hop is Virtual Appliance VM and send hop to the target VM

Create connectivity between virtual networks

There are multiple ways to connect VNets. The sections below describe different ways to connect virtual networks.



Cloud-Only Virtual Networks

You can choose not to make any kind of virtual private network (VPN) connection to a VNet. Instead, when you create a VM or cloud service, you can specify endpoints that external clients can connect to. An endpoint is a VIP and a port number. Therefore an endpoint can be used only for a specific protocol, such as connecting a Remote Desktop Protocol (RDP) client or browsing a website. These VNets are known as cloud-only virtual networks. A dynamic routing gateway is not required in the VNet. Endpoints are published to the Internet, so they can be used by anyone with an Internet connection, including your on-premises computers.

Point-to-Site VPNs

A simple way to connect a VPN to an Azure VNet is to use a Point-to-Site VPN. In these VPNs, you configure the connection on individual on-premises computers. No extra hardware is required but you must complete the

configuration procedure on every computer that you want to connect to the VNet. Point-to-site VPNs can be used by the client computer to connect to a VNet from any location with an Internet connection. Once the VPN is connected, the client computer can access all VMs and cloud services in the VNet as if they were running on the local network.

Site-to-Site VPNs

To connect **all the computers** in a physical site to an Azure VNet, you can create a Site-to-Site VPN. In this configuration, you do not need to configure individual computers to connect to the VNet, **instead you configure a VPN device**, which acts as a gateway to the VNet.

When you use the Site-to-Site IPsec steps, you create and configure the local network gateways manually. The local network gateway for each VNet treats the other VNet as a local site. This lets you specify additional address space for the local network gateway in order to route traffic. If the address space for a VNet changes, you need to update the corresponding local network gateway to reflect that. It does not automatically update.

VNet-to-VNet

Connecting a virtual network to another virtual network (VNet-to-VNet) is similar to connecting a virtual network to an on-premises site location. Both connectivity types use a VPN gateway to provide a secure tunnel using IPsec/IKE. The VNets you connect can be in **different subscriptions** and **different regions**.

The difference between the S2S AND V2V connection types is the way the local network gateway is configured. When you create a VNet-to-VNet connection, you do not see the local network gateway address space. It is automatically created and populated. If you update the address space for one VNet, the other VNet automatically knows to route to the updated address space. Creating a VNet-to-VNet connection is typically faster and easier than creating a Site-to-Site connection between VNets.

You can combine VNet to VNet communication with multi-site configurations. This lets you establish network topologies that combine cross-premises connectivity with inter-virtual network connectivity.

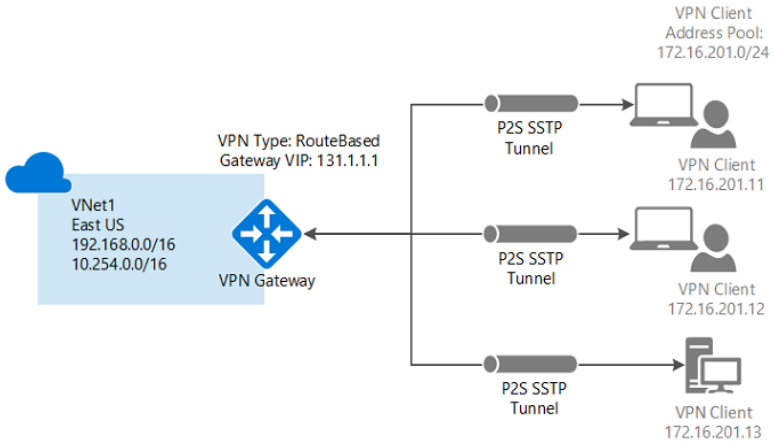
VNet peering

You may want to consider connecting your VNets using VNet Peering. VNet peering does not use a VPN gateway and has different constraints. Additionally, VNet peering pricing is calculated differently than VNet-to-VNet VPN Gateway pricing

ExpressRoute

ExpressRoute is a service that enables Azure customers to create a dedicated connection to Azure, which does not connect through the public Internet. This contrasts with VPNs, which use encryption to tunnel securely through the public Internet. Because ExpressRoute connections are dedicated, they can offer faster speeds, higher security, lower latencies, and higher reliability than VPNs.

Create a Point-to-Site VPN



Generate Certificates – Self signed root certificate for P2S connection

1. Open the Powershell command window and execute the following (Do not close the window)

```
$cert = New-SelfSignedCertificate -Type Custom -KeySpec Signature `
-Subject "CN=P2SRootCert" -KeyExportPolicy Exportable `
-HashAlgorithm sha256 -KeyLength 2048 `
-CertStoreLocation "Cert:\CurrentUser\My" -KeyUsageProperty Sign -KeyUsage CertSign
```

2. **To obtain the public key (.cer file)**
    1. Search → **Manage User Certificates** → Personal → Certificates

       or
    2. **MMC → File → Add/Remove Snap-In → Certificates → Add → OK**

       open **certmgr.msc**., typically in **'Certificates - Current User\Personal\Certificates'**.
    3. Locate the self-signed root certificate **(P2SRootCert)** → Right Click → **All Tasks**, and then click **Export**. This opens the **Certificate Export Wizard**.
    4. In the Wizard, click **Next**. Select **No, do not export the private key**, and then click **Next**.
    5. On the **Export File Format** page, select **Base-64 encoded X.509 (.CER).**, and then click **Next**.
    6. **File to Export**, **Browse** = d:\P2SRootCert.cer → **Next**.
    7. Click **Finish** to export the certificate. You will see **The export was successful**. Click **OK** to close the wizard.

A client certificate that is present on the device is used to authenticate the connecting user. Client certificates are generated from a trusted root certificate and then installed on each client computer. You can use a root certificate that was generated using an Enterprise solution, or you can generate a self-signed certificate.

The validation of the client certificate is performed by the VPN gateway and happens during establishment of the P2S VPN connection. The root certificate is required for the validation and must be uploaded to Azure

3. **Generate a client certificate: Execute the following command in the same PowerShell window opened earlier.**

```
New-SelfSignedCertificate -Type Custom -KeySpec Signature `
-Subject "CN=P2SChildCert" -KeyExportPolicy Exportable `
-HashAlgorithm sha256 -KeyLength 2048 `
-CertStoreLocation "Cert:\CurrentUser\My" `
-Signer $cert -TextExtension @("2.5.29.37={text}1.3.6.1.5.5.7.3.2")
```

More about Certficates:

https://docs.microsoft.com/en-us/azure/vpn-gateway/vpn-gateway-certificates-point-to-site

Ensure that a Gateway Subnet is already created in a VNet

4. Select VNet → Subnets → **+ Gateway subnet** → OK

Create a Virtual Network Gateway

5. All Services → **Virtual Network Gateway** → +Add
    a) Name=TestVNetGateway, . . . ,
    b) Gateway type = VPN
    c) VPN type = Route-based
    d) SKU = Basic (table below)
    e) Choose a virtual network,
    f) Create a New IP
    g) Create

Note: Provisioning a virtual network gateway may take up to 45 minutes.

About VPN Types:

1. **RouteBased**: RouteBased VPNs use "routes" in the IP forwarding or routing table to direct packets into their corresponding tunnel interfaces. The tunnel interfaces then encrypt or decrypt the packets in and out of the tunnels.
2. **PolicyBased**: Policy-based VPNs encrypt and direct packets through IPsec tunnels based on the IPsec policies configured with the combinations of address prefixes between your on-premises network and the Azure VNet.
    1. PolicyBased VPNs can **only** be used on the Basic gateway SKU.
    2. You can have only **1 tunnel** when using a PolicyBased VPN.
    3. You can only use PolicyBased VPNs for **S2S connections**.

Which Gateway SKUs Support P2S VPN?

SKU	P2S Connections	S2S/VNet-to-VNet Tunnels	Aggregate Throughput Benchmark
Basic	128	Max. 30	100 Mbps
VpnGw1	128	Max. 30	650 Mbps
VpnGw2	128	Max. 30	1Gbps
VpnGw3	128	Max. 10	1.25 Gbps

Upload the root certificate .cer file

6. Open the Root certificate (not child) with a text editor, such as Notepad. Copy the content between -----BEGIN CERTIFICATE------ and -----END CERTIFICATE------
7. Select VNetGateway created earlier → **Point-to-site configuration**,
    1. **Address Pool**=172.16.201.0/24 (is the pool of IP addresses from which clients that connect will receive an IP address.)
    2. Tunnel type = IKEv2
    3. **Root Certificates**: Name=RootCert1, Public Certficate Data <Value copied in prev step>

Note: You can add up to **20 trusted** root certificates.

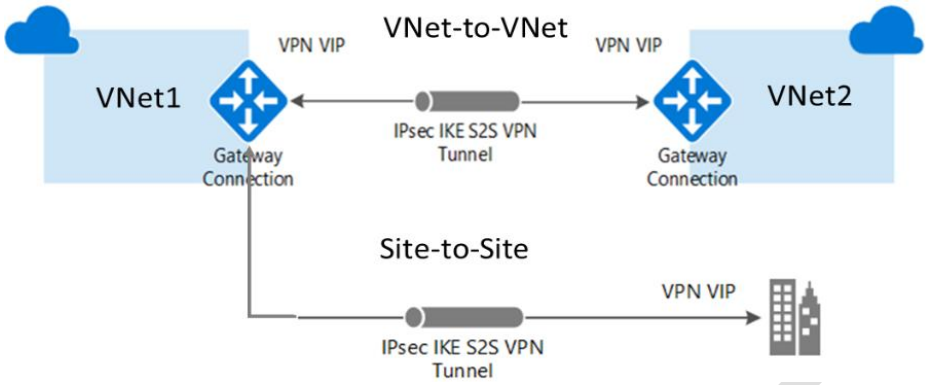
Download and Install VPN client

8. Point-to-site configuration → Download VPN client
9. Select X64 → Download
10. Execute the downloaded EXE file
11. Client Computer → Network Settings → VPN
12. Click on TestVNet and connect to VNet.
13. To verify that your VPN connection is active, open an elevated command prompt, and **run *ipconfig/all***.
14. You can also use the Private IP of any VM in the VNet and open it in Web Browser to the response of the page.
15. **You can RDP to one of the VM and browse websites of other VM in the other Vnet using Private IP.**

Create and configure VNET to VNET

You can connect your VNets with a VNet-to-VNet VPN connection.

Uses an Azure VPN gateway to provide a secure tunnel using IPSec/IKE. Though the traffic is secured in VPN, it leaves Azure and travels over public internet for transport.



With a VNet-to-VNet connection your VNets can be:

- in the same or different regions.
- in the same or different subscriptions.
- in the same or different deployment models.
- in Azure or on-premises.

Note that VNet-to-VNet traffic within the **same region is free** for both directions when using a VPN gateway connection. Cross region VNet-to-VNet egress traffic is charged with the outbound inter-VNet data transfer rates based on the source regions. Visit https://azure.microsoft.com/en-us/pricing/details/vpn-gateway/ for Pricing details.

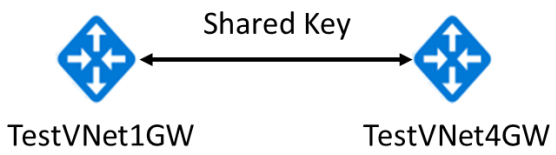
In the example, the virtual networks are in the same subscription, but in different resource groups. If your VNets are in different subscriptions, you can't create the connection in the portal. You can use PowerShell or CLI.

1. Create and configure the first VNet TestVNet1
2. Create a gateway subnet
3. Create a virtual network gateway – TestVNet1GW

4. Create and configure the second VNet TestVNet2
5. Create a gateway subnet
6. Create a virtual network gateway – TestVNet2GW

Configuring and Connect VPN Gateways

Once your VPN gateways are created, you can create the connection between them. If your VNets are in the same subscription, you can use the portal.



7. Configure the TestVNet1 gateway connection
    - Select TestVNet1GW → Connections → +Add
    - Name = TestVNet1toTestVNet2
    - Connection type = VNet-to-VNet
    - Second virtual network gateway = TestVNet2GW
    - **Shared key = "abc123"**
8. Configure the TestVNet2 gateway connection

    Follow the steps from the previous section, replacing the values to create a connection from TestVNet2 to TestVNet1. Make sure that you use the **same shared key**.
9. Verify your connections
    - Select Virtual Network Gateway → Connections
    - Ensure that Status value change to **Succeeded and Connected**.

For example, you could add a connection betweenTestVNet1GW and TestVNet2GW. In the Shared key field, type a shared key for your connection. You can generate or create this key yourself.

10. **You can also RDP to one of the VM and browse websites of other VM in the other Vnet using Private IP.**

Create and Configure VNet Peering

Virtual network peering enables you to seamlessly connect two Azure virtual networks. Once peered, the virtual networks appear as one, for connectivity purposes.

The traffic between virtual machines in the peered virtual networks is routed through the **Microsoft backbone infrastructure**, much like traffic is routed between virtual machines in the same virtual network, through *private* IP addresses only.

Azure supports:

- VNet peering - connecting VNets within the **same Azure region.**
- Global VNet peering - connecting VNets across different Azure regions. Though not available in all regions.

Benefits

1. Its best alternative to VPN for vNets in same region because all network traffic between peered virtual networks is **private and routed over Azure internal networks** instead of public internet.
2. A low-latency, high-bandwidth connection between resources in different virtual networks.
3. The ability for resources in one virtual network to communicate with resources in a different virtual network, once the virtual networks are peered.

4. The ability to transfer data across Azure subscriptions, deployment models, and across Azure regions.

Pros and Cons over VPN Gateway

Pros

1. Faster and easier to setup than VPN
2. No Public IP required.

Cons

11. Peering relationships are not transitive.

    If you create peerings between:

    - VirtualNetwork1 & VirtualNetwork2
    - VirtualNetwork2 & VirtualNetwork3

    There is no peering between VirtualNetwork1 and VirtualNetwork3 through VirtualNetwork2.
12. You can't add address ranges to, or delete address ranges from a virtual network's address space once a virtual network is peered with another virtual network
13. Cannot use overlapping address spaces.

Pricing:

https://azure.microsoft.com/en-us/pricing/details/virtual-network/

Configuring a Peering

https://microsoftlearning.github.io/20533-ImplementingMicrosoftAzureInfrastructureSolutions/Instructions/20533E_LAB_AK_02.html#exercise-1-using-the-azure-portal-to-configure-vnet-peering

1. Select the Vnet → Settings → Peerings
2. Select + Add
3. Enter Name . . . and other details

- **I know my resource ID**

  If you have read access to the virtual network you want to peer with, leave this checkbox unchecked.

  If you don't have read access to the virtual network or subscription you want to peer with, check this box.
- **Allow virtual network access:**

  Select **Enabled** (default) if you want to enable communication between the two virtual networks. You might select **Disabled** if you've peered a virtual network with another virtual network, but occasionally want to disable traffic flow between the two virtual networks.
- **Allow forwarded traffic:** Check this box to allow traffic *forwarded* by a network virtual appliance in a virtual network (that didn't originate from the virtual network) to flow to this virtual network through a peering. You

don't need to check this setting if traffic is forwarded between virtual networks through an Azure VPN Gateway.

- **Allow gateway transit:** Check this box if you have a virtual network gateway attached to this virtual network and want to allow traffic from the peered virtual network to flow through the gateway.
- **Use remote gateways:** Check this box to allow traffic from this virtual network to flow through a virtual network gateway attached to the virtual network you're peering with.

Using PowerShell Commands

1. Create a new resource group

   New-AzureRmResourceGroup -Name TestRG -Location centralus

2. Create a new VNet named *TestVNet*

   New-AzureRmVirtualNetwork -ResourceGroupName TestRG -Name **TestVNet** -AddressPrefix 192.168.0.0/16 -Location centralus

3. Store the virtual network object in a variable

   $vnet = **Get-AzureRmVirtualNetwork** -ResourceGroupName TestRG -Name TestVNet

4. Add a subnet to the new VNet variable

   Add-AzureRmVirtualNetworkSubnetConfig -Name FrontEndSubnet -VirtualNetwork $vnet -AddressPrefix 192.168.1.0/24

5. Repeat above step for each subnet you want to create

   Add-AzureRmVirtualNetworkSubnetConfig -Name BackEndSubnet -VirtualNetwork $vnet -AddressPrefix 192.168.2.0/24

6. Although you create subnets, they currently only exist in the local variable used to retrieve the VNet you create in step 4 above.

   Set-AzureRmVirtualNetwork -VirtualNetwork $vnet

7. **Create a Public IP address** (PIP) resource named PublicIP, to be used by a front-end IP pool:

   $publicIP = **New-AzureRmPublicIpAddress** -Name PublicIp -ResourceGroupName TestRG -Location centralus –AllocationMethod Static -DomainNameLabel DssWebWM1

8. **Create the NIC** attached to a subnet, with a public facing IP, and a static private IP

   $NIC = **New-AzureRmNetworkInterface** -Name TestNic -ResourceGroupName TestRG –Location centralus -SubnetId $vnet.Subnets[0].Id -PublicIpAddressId $publicIP.Id -PrivateIpAddress "10.0.1.4"