**Configure and Manage Azure Virtual Networks**

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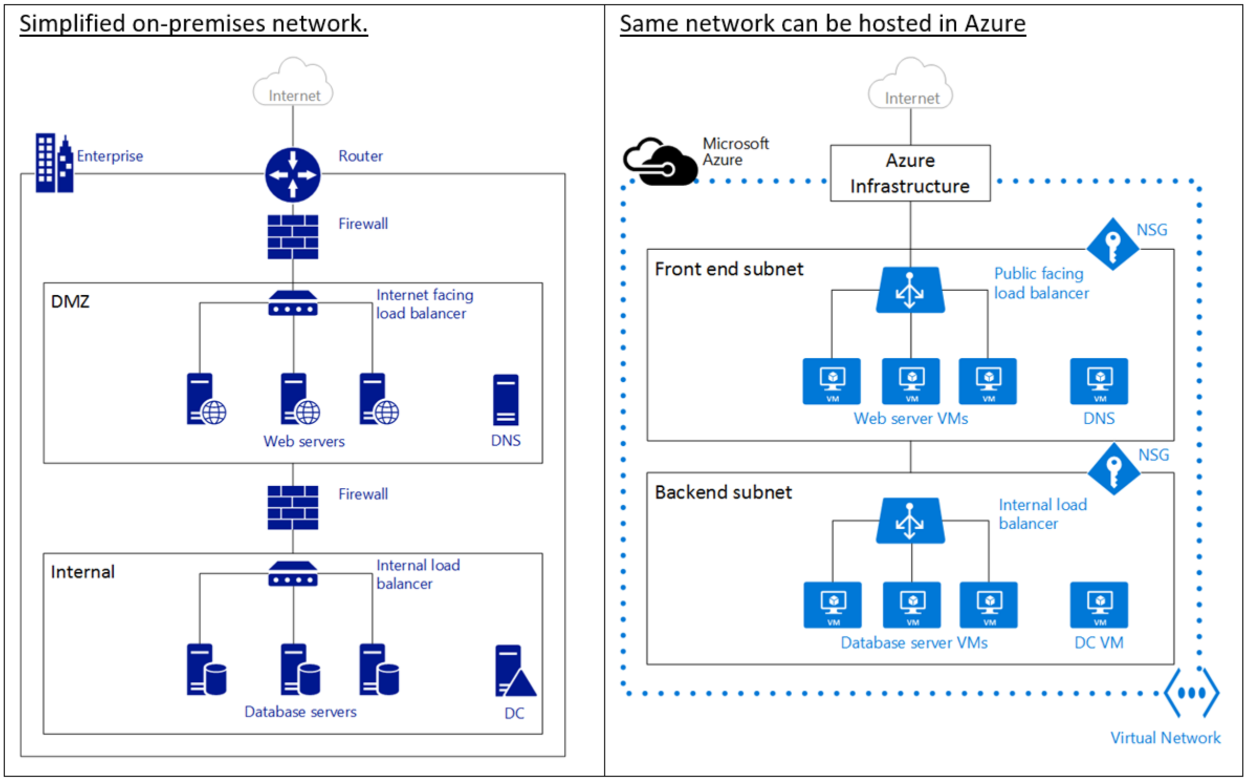
## Overview of Azure Networking

- 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.



*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:**

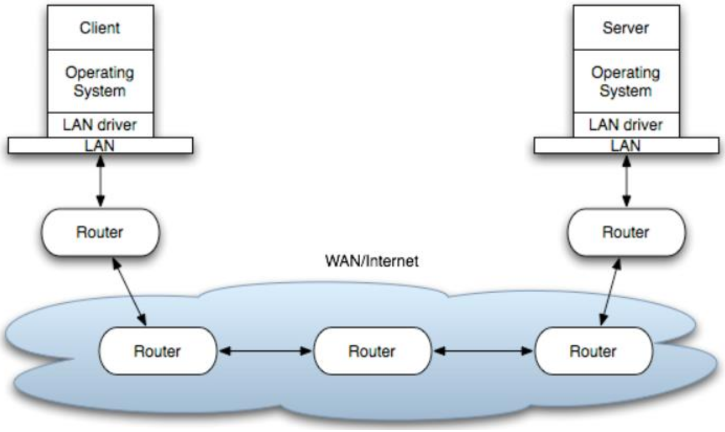
- There is **no extra cost** for using Virtual Networks in Azure.
- The compute instances launched within the Vnet will be charged the standard rates as described in Azure VM Pricing.
- The VPN Gateways and Public IP Addresses used in the VNet will also be charged standard rates.

## 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 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 in a VNet can be controlled using Network Security groups and Azure Firewall.
- **Access to VMs within the VNet**. 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 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.

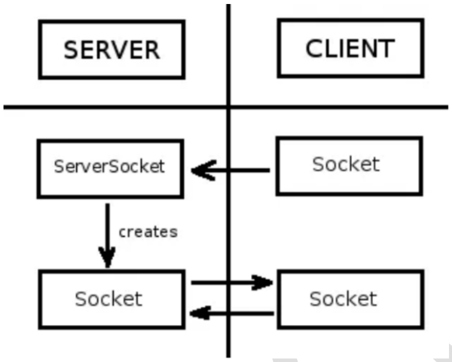
Note: The most important thing about Windows Azure virtual networks is that you cannot add an existing virtual machine to a newly created virtual network. It is important that if you want to leverage virtual networking in Azure that you must create the virtual networks **BEFORE** creating your virtual 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

## OSI Layers in Network Communication

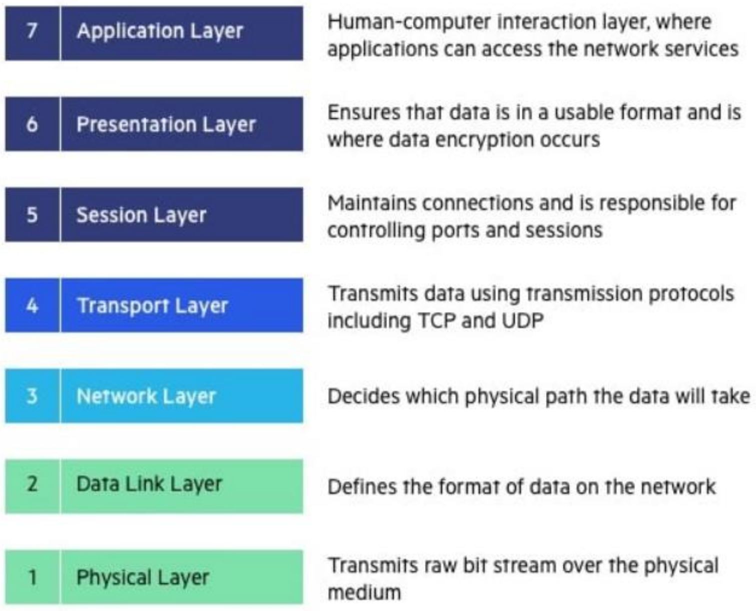


Socket = IP + Port No

HTTP = 80, HTTPS = 443, FTP=21…SQL Server DB = 1433, RDP=3389…..



**OSI Layers:**



| | | |
|---|---|---|
| 7 | Application Layer | Human-computer interaction layer, where applications can access the network services |
| 6 | Presentation Layer | Ensures that data is in a usable format and is where data encryption occurs |
| 5 | Session Layer | Maintains connections and is responsible for controlling ports and sessions |
| 4 | Transport Layer | Transmits data using transmission protocols including TCP and UDP |
| 3 | Network Layer | Decides which physical path the data will take |
| 2 | Data Link Layer | Defines the format of data on the network |
| 1 | Physical Layer | Transmits raw bit stream over the physical medium |

## 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 (Private IP):**

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**

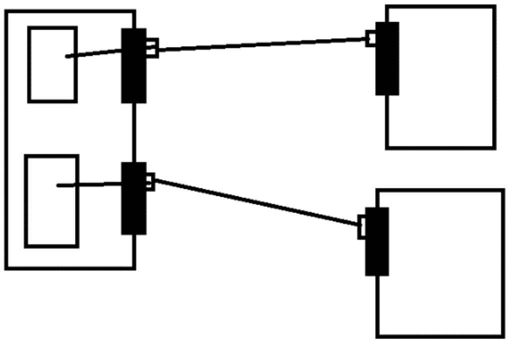
- There are two methods in which an IP address is allocated to a *public* IP resource - ***dynamic*** or ***static.***
  - In the **dynamic** allocation method the IP address is **not** allocated at the time of its creation. Instead, the public IP address is allocated when you start (or create) the associated 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
- Public IP address is paid service.

**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 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.

- **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 16 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 **allowed or denied** based on **source IP address, source port, destination IP address, and destination port.**

- **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 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.

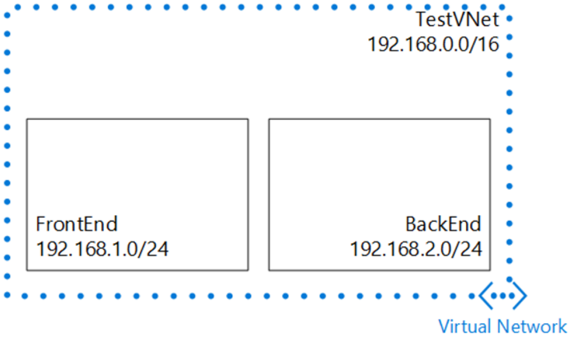
- **Azure DNS:** The Domain Name System (DNS) enables clients to resolve user-friendly fully qualified domain names (FQDNs), such as www.adatum.com, to IP addresses**.** Azure Domain Name System (DNS) allows you to host your domains with your Azure apps. By hosting your domains in Azure, you can manage 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=192.162.0.0/16, Subnet name="**Frontend-subnet**", Subnet Address Range=192.168.1.0/24, Select Resource Group → Create

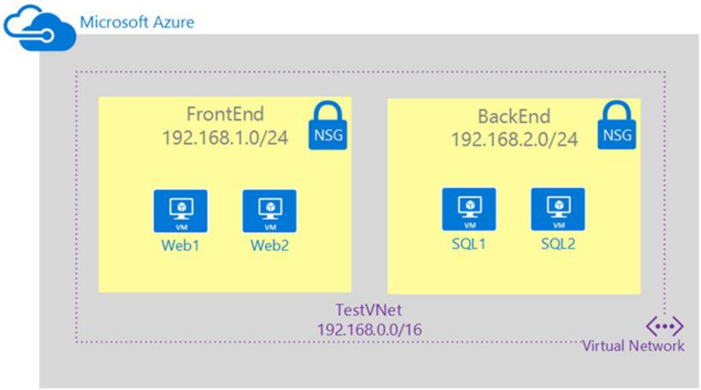
**3.** Wait for the VNet to be created, → **Virtual network** blade, click **All settings** → **Subnets** → **Add** a new Subnet. (Name=**Backend-subnet**, Address space=192.168.2.0/24, Leave NSG and Route table=None → OK.

## 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 **Demo-vnet** virtual network, as described below:

- **Frontend-nsg**. 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.
- **Backend-nsg**. 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.



**4.** **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=1000, 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=1001, 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

5. **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=1001, 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=1002, 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=1000, 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

6. Azure portal → On the Hub menu, click New → Compute → Windows Server 2016 Datacenter.

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

7. On the Windows Server 2016 Datacenter page, under Select a deployment model = Resource Manager → Create.

8. 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.

9. Click Create

**Create the following two VM**

**Demo-vm**

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 Internet: OutBound

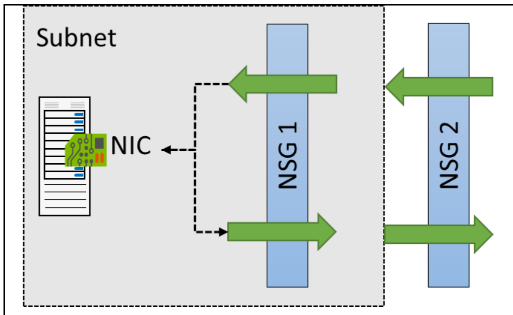
Accessed

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

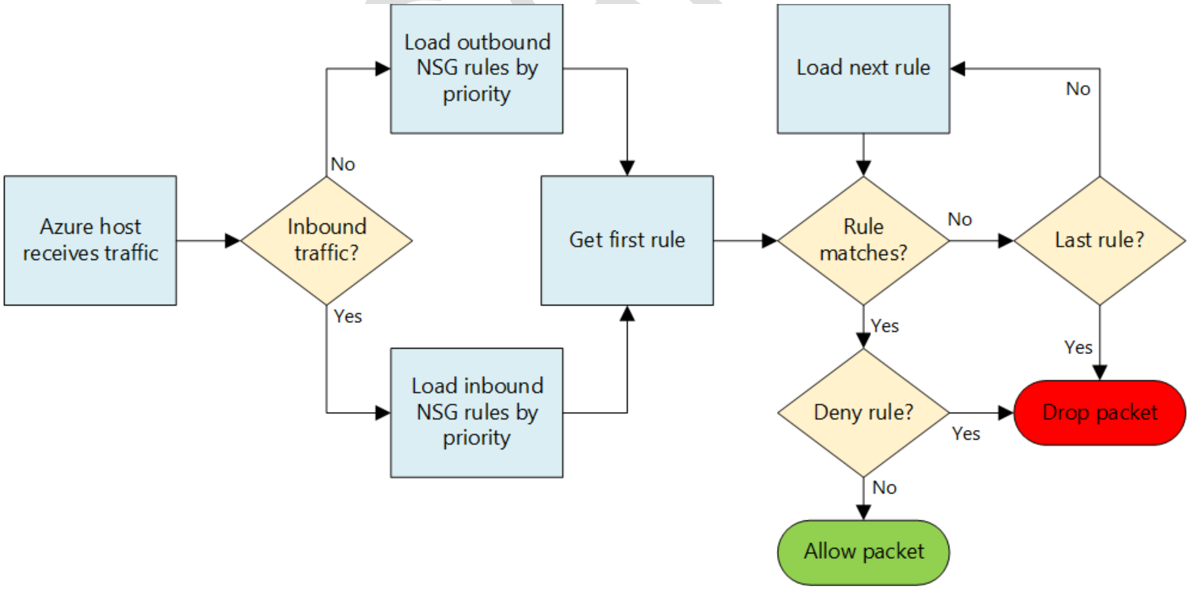
Web2 http://<ip> or http://<dnsname>

**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:**

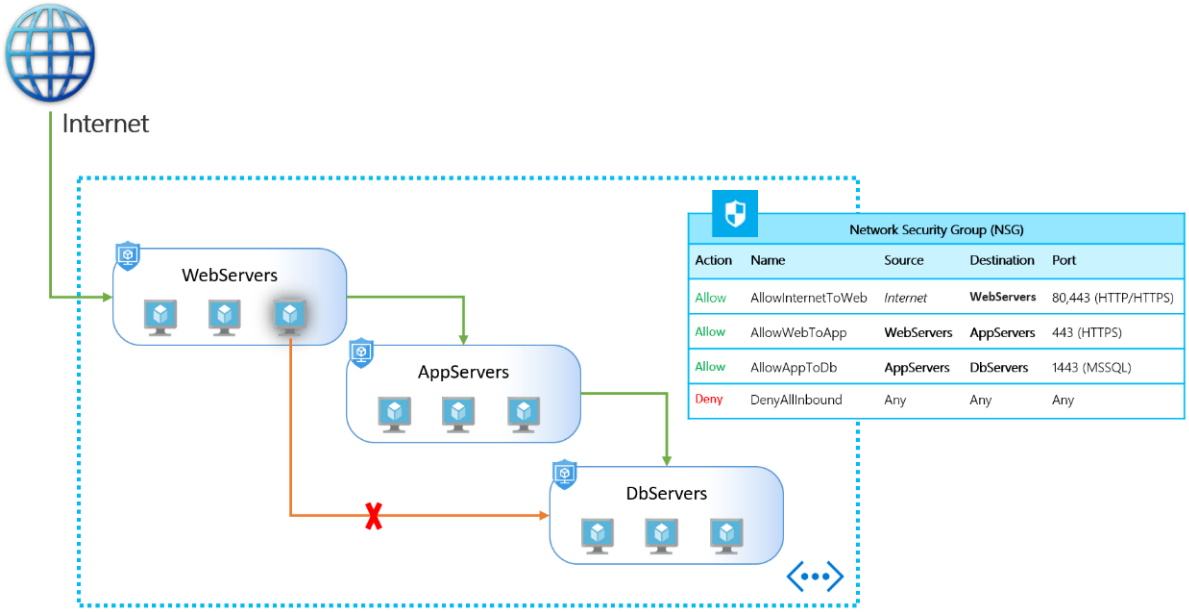
Select the VM → Settings → Networking → Click on **Effective security rules**

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.

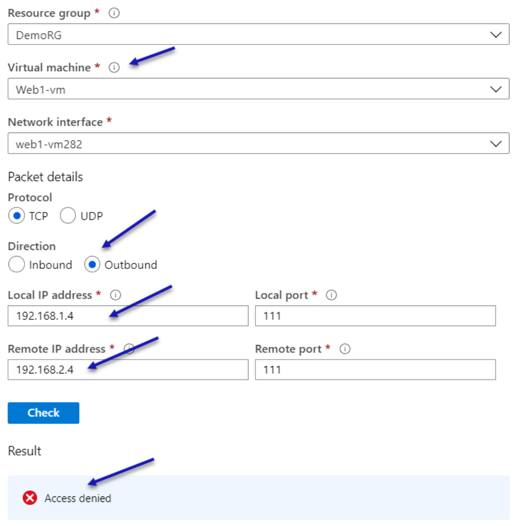
## Application Security Groups

Application security groups enable you to configure network security as a natural extension of an application's structure, allowing you to group virtual machines and define network security policies based on those groups. This feature allows you to reuse your security policy at scale without manual maintenance of explicit IP addresses. The platform handles the complexity of explicit IP addresses and multiple rule sets, allowing you to focus on your business logic.



| Action | Name | Source | Destination | Port |
|---|---|---|---|---|
| Allow | AllowInternetToWeb | *Internet* | **WebServers** | 80,443 (HTTP/HTTPS) |
| Allow | AllowWebToApp | **WebServers** | **AppServers** | 443 (HTTPS) |
| Allow | AllowAppToDb | **AppServers** | **DbServers** | 1443 (MSSQL) |
| Deny | DenyAllInbound | Any | Any | Any |

1. Create two new Application Secuirty Groups
   - WebServers-asg
   - DbServers-asg
2. Attach them to respective VM: VM → Networking → Application Securty Group tab
3. Use **Network Watcher** and note that **IP Flow verify** is **success** from Web1-vm to Db1-vm
4. Create an NSG **outbound rule** to **deny** traffic from WebServers to DbServers
5. Wait for couple of minutes.
6. Use **Network Watcher** and note that **IP Flow verify** is **failed** from Web1-vm to Db1-vm



Resource group * ⓘ
DemoRG

Virtual machine * ⓘ
Web1-vm

Network interface *
web1-vm282

Packet details

Protocol
● TCP ○ UDP

Direction
○ Inbound ● Outbound

Local IP address * ⓘ
192.168.1.4

Local port * ⓘ
111

Remote IP address * ⓘ
192.168.2.4

Remote port * ⓘ
111

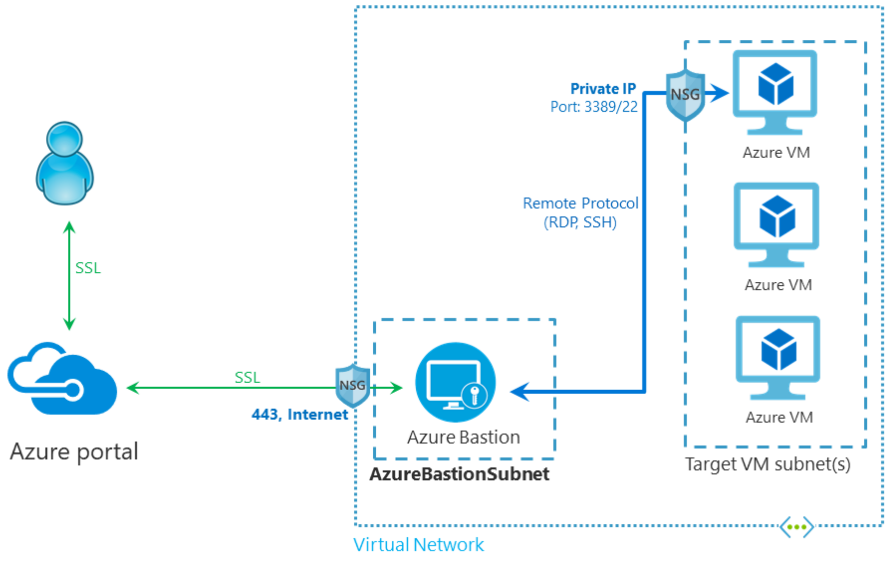
Check

Result

Access denied

## Azure Bastion

Azure Bastion is a fully managed PaaS service that provides secure and seamless RDP and SSH access to your virtual machines directly through the Azure Portal. Azure Bastion is provisioned directly in your Virtual Network (VNet) and supports all VMs in your Virtual Network (VNet) using SSL without any exposure through public IP addresses.



In this diagram:

- The Bastion host is deployed in the virtual network.
- The user connects to the Azure portal using any HTML5 browser.
- The user selects the virtual machine to **connect** to.

- With a single click, the RDP/SSH session opens in the browser.
- No public IP is required on the Azure VM.

**The following features are available:**

- **RDP and SSH directly in Azure portal:** You can directly get to the RDP and SSH session directly in the Azure portal using a single click seamless experience.
- **Remote Session over SSL and firewall traversal for RDP/SSH:** Azure Bastion uses an HTML5 based web client that is automatically streamed to your local device, so that you get your RDP/SSH session over SSL on port 443 enabling you to traverse corporate firewalls securely.
- **No Public IP required on the Azure VM:** Azure Bastion opens the RDP/SSH connection to your Azure virtual machine using private IP on your VM. You don't need a public IP on your virtual machine.
- **No hassle of managing NSGs:** Azure Bastion is a fully managed platform PaaS service from Azure that is hardened internally to provide you secure RDP/SSH connectivity. You don't need to apply any NSGs on Azure Bastion subnet. Because Azure Bastion connects to your virtual machines over private IP, you can configure your NSGs to allow RDP/SSH from Azure Bastion only. This removes the hassle of managing NSGs each time you need to securely connect to your virtual machines.

**Create a bastion host**

1. Azure Vnet → Subnet → Create a **New Subnet** by name **AzureBastionSubnet** (You must use a subnet of at least /27 or larger eg: /26, /25 and …)
2. Azure Portal → + New → Bastion

**Connect to VM**

3. Azure VM → **Connect** → **Bastion** → Provide the RDP Username and Password → Connect

**Note: You have to allow popup .**

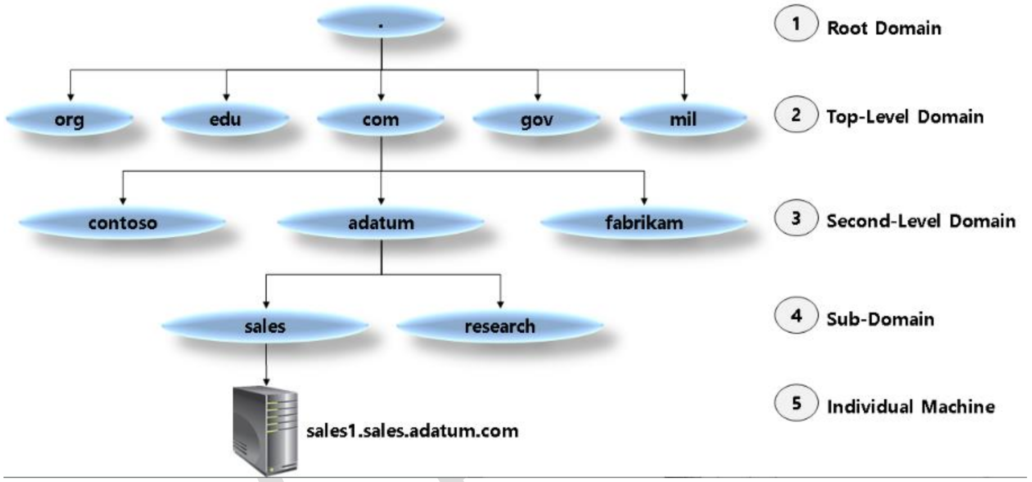
## Azure DNS

- 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.
- Applications requiring automatic DNS management can integrate with the service via the REST API and SDKs.

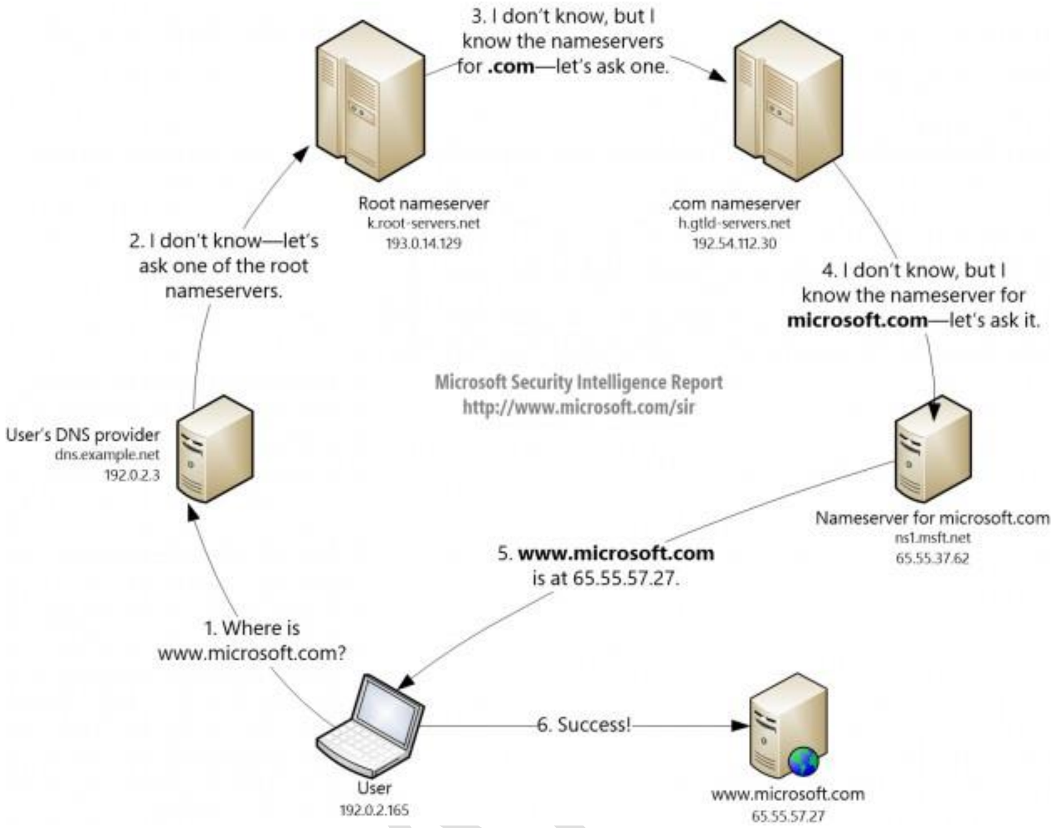
- When you add a new DNS record, the Azure DNS name servers are updated in a few seconds so you don't have to wait long before that DNS record can be used.
- Azure DNS does not currently support purchasing of domain names.

**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.


3. I don't know, but I know the nameservers for .com—let's ask one.
Root nameserver
k.root-servers.net
193.0.14.129
.com nameserver
h.gtld-servers.net
192.54.112.30
2. I don't know—let's ask one of the root nameservers.
4. I don't know, but I know the nameserver for microsoft.com—let's ask it.
Microsoft Security Intelligence Report
http://www.microsoft.com/sir
User's DNS provider
dns.example.net
192.0.2.3
Nameserver for microsoft.com
ns1.msft.net
65.55.37.62
5. www.microsoft.com is at 65.55.57.27.
1. Where is www.microsoft.com?
6. Success!
User
192.0.2.165
www.microsoft.com
65.55.57.27

**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...

**<u>DNS Zone:</u>**

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:**

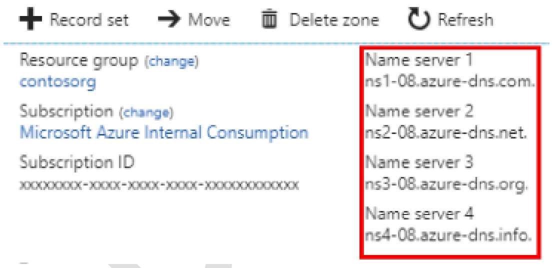
**1.** Buy a Domain Name from a Registrar (eg: godaddy.com is registrar)

**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



Resource group (change)
contosorg

Subscription (change)
Microsoft Azure Internal Consumption

Subscription ID
xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxxxx

Name server 1
ns1-08.azure-dns.com.

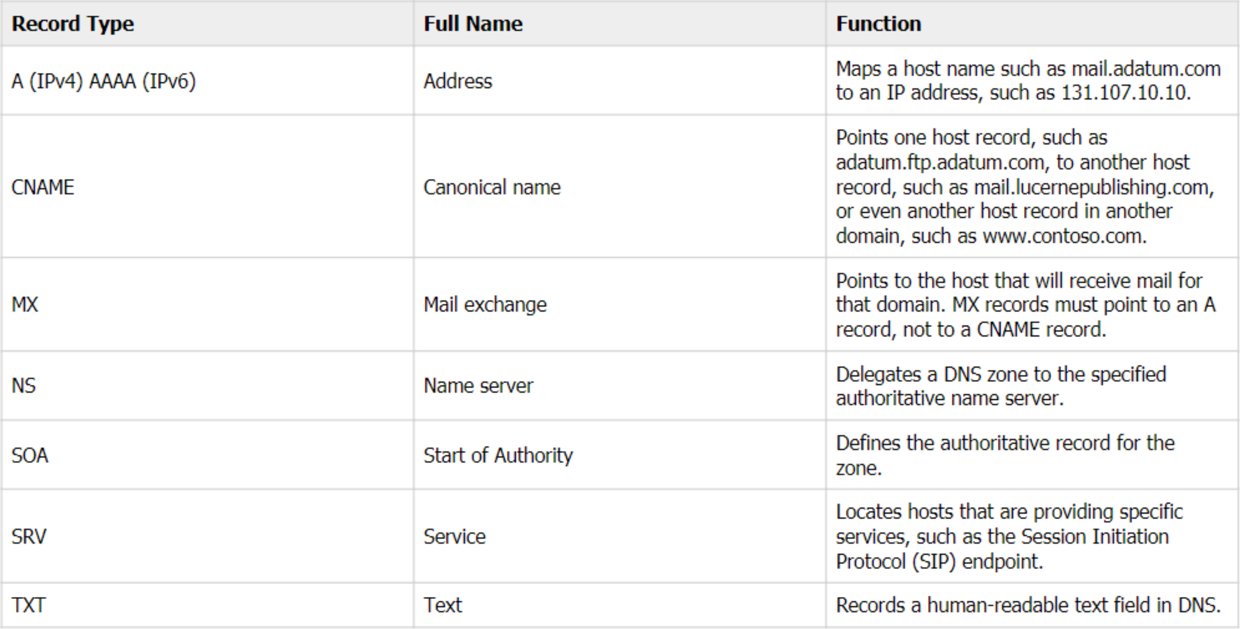
Name server 2
ns2-08.azure-dns.net.

Name server 3
ns3-08.azure-dns.org.

Name server 4
ns4-08.azure-dns.info.

**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**

Private DNS Zone can be linked to multiple VNETs and they can be in different Azure AD Tentant also.

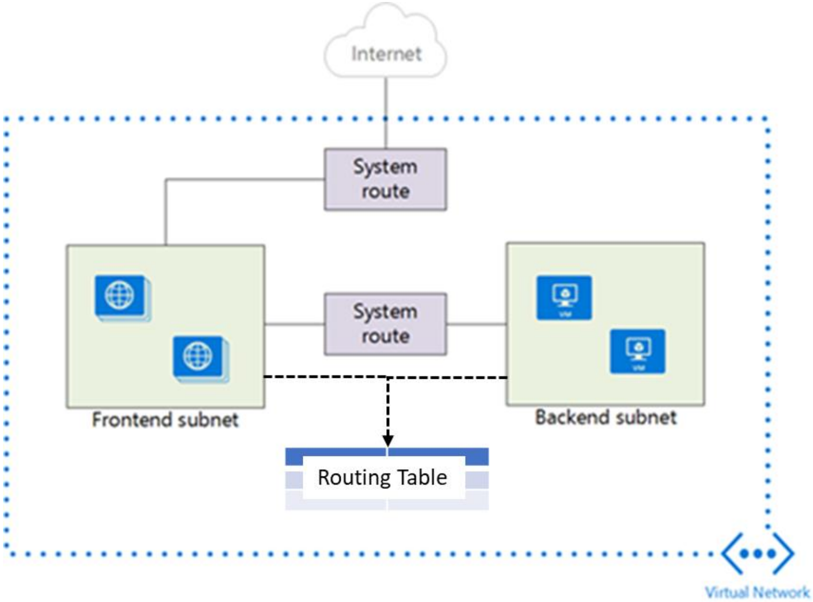
Here Domain Names are mapped Private IP Address.

## 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.



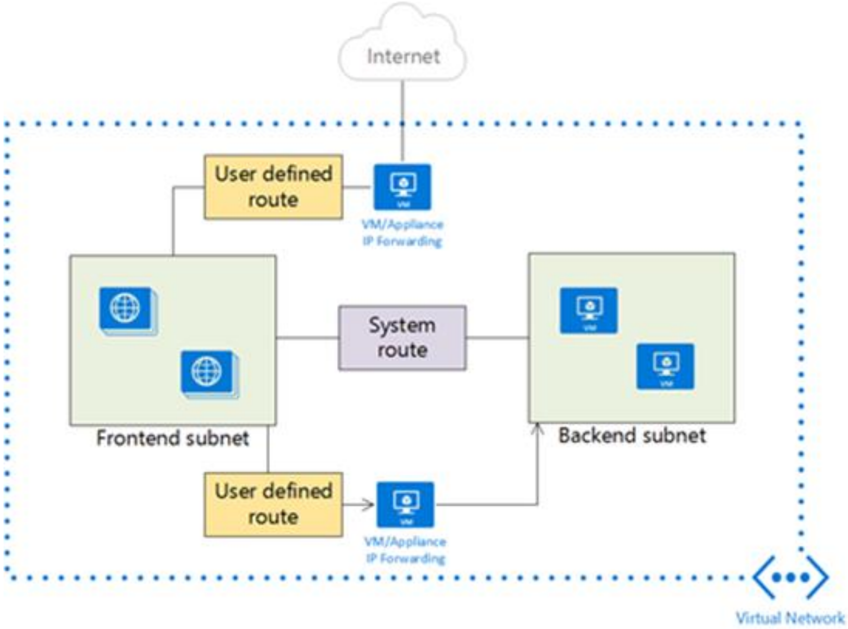
Information about the **system routes** is recorded in a **route table**. A route table contains a set of **rules**, called **routes**, that specifies how packets should be routed in a virtual network. Route tables are **associated to subnet**s, and each packet leaving a subnet is handled based on the 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.

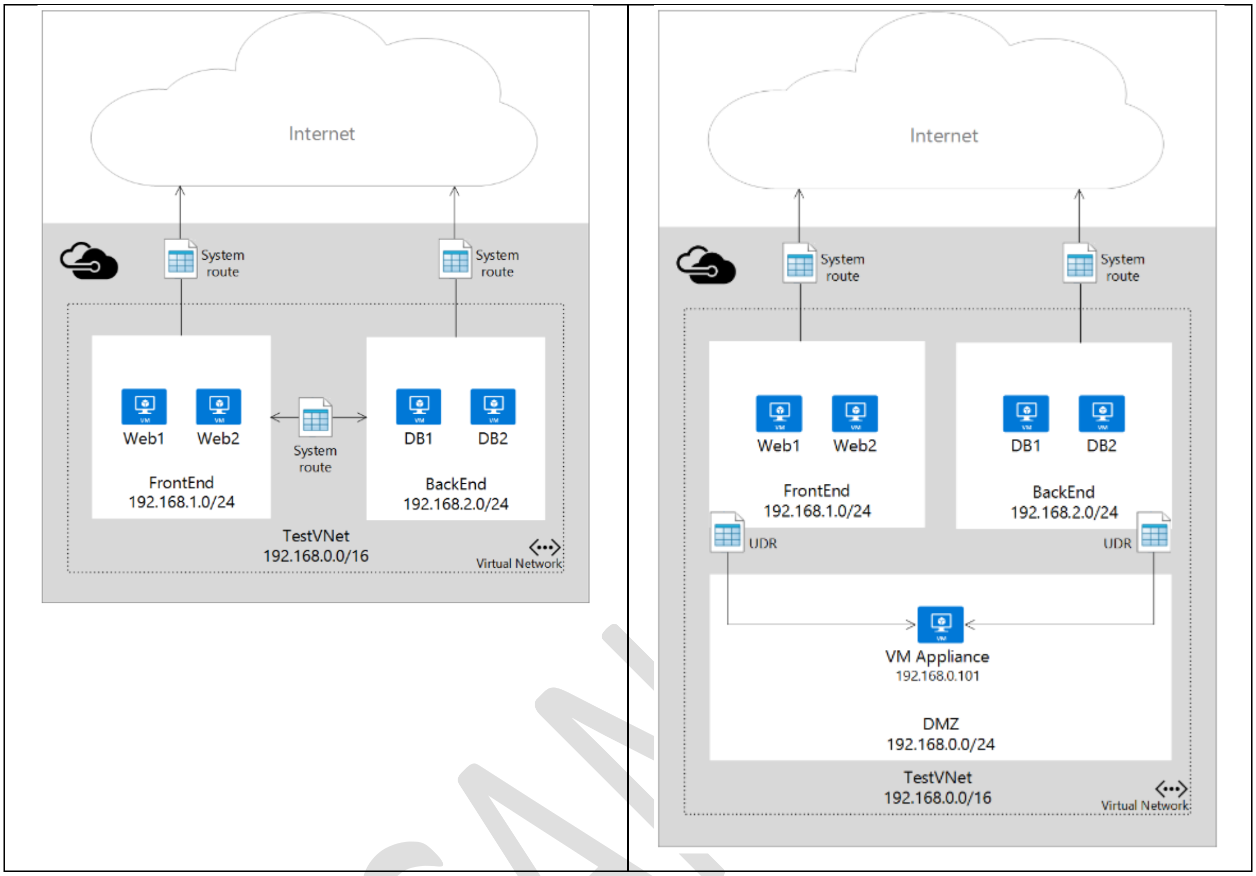
However, you may need to create a route table and add one or more routes in specific cases, such as:

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



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.”

**Example of Virtual Appliance: Palo Alto Networks VM-Series.**

**Create User Defined Routes (UDR) :**

1. Create a **New Subnet (name=VirtualAppliance-subnet)** with Address Prefix 192.168.3.0/24.
2. Create a **new VM** to be used for virtual appliance with private IP address **192.168.3.4**. (preferably static)

**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=**Frontend-to-Backend-Subnet-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 (used for Virtual Appliance):**

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

10. 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**

11. 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
       ```

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

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

**Rules Explained:**

https://docs.microsoft.com/en-us/azure/virtual-network/virtual-networks-udr-overview

## Azure Firewall

Controlling **outbound network access** is an important part of an overall network security plan. For example, you may want to limit access to web sites. Or, you may want to limit the outbound IP addresses and ports that can be accessed.

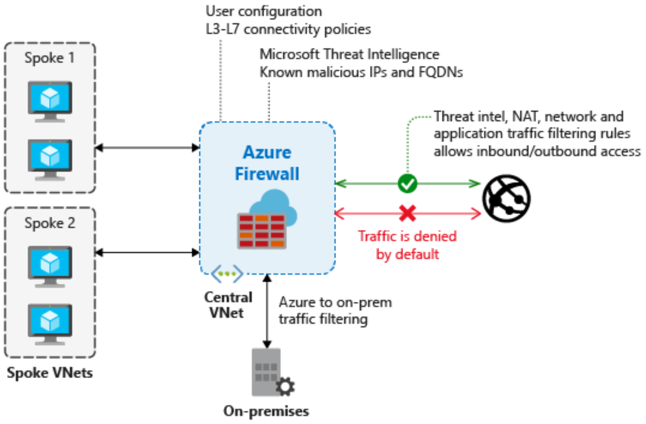
With Azure Firewall, you can configure:

- **Application rules** that define fully qualified domain names (FQDNs) that can be accessed from a subnet (having a route table)
- **Network rules** that define source address, protocol, destination port, and destination address.

**Key Features of Azure Firewall:**

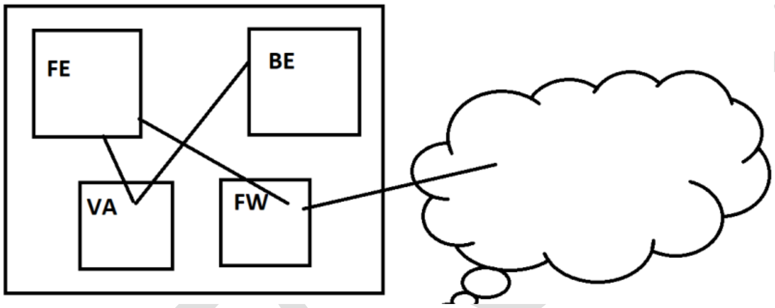
- Azure Firewall is a managed, cloud-based network security service that protects your Azure Virtual Network resources.
- It's a fully stateful firewall as a service with built-in **high availability and unrestricted cloud scalability**.
- Azure Firewall **can scale up** as much as you need to accommodate changing network traffic flows, so you don't need to budget for your peak traffic.
- Application FQDN filtering rules. You can limit outbound HTTP and HTTPS traffic to a specified list of FQDNs, including wildcards. This feature doesn’t require SSL termination.
- Threat intelligence

- Multiple public IP addresses
- Integrated with Azure Monitor. All events are integrated with Azure Monitor, allowing you to archive logs to a storage account, stream events to your event hub, or send events to Azure Monitor logs.


User configuration
L3-L7 connectivity policies
Microsoft Threat Intelligence
Known malicious IPs and FQDNs
Spoke 1
Spoke 2
Spoke VNets
Azure Firewall
Threat intel, NAT, network and application traffic filtering rules allows inbound/outbound access
Traffic is denied by default
Central VNet
Azure to on-prem traffic filtering
On-premises

Pricing: https://azure.microsoft.com/en-in/pricing/details/azure-firewall/

**Requirement:**



**Pre-requisite**

**Demo-vnet** = 192.168.0.0/16

Frontend-subnet = 192.168.1.0/24

VM: DemoFE-vm = Allow RDP/HTTP, Private IP: 192.168.1.4

Backend-subnet = 192.168.2.0/24

VM: DemoBE-vm = Allow RDP/HTTP, Private IP: 192.168.2.4

Jump-subnet = 192.168.3.0/24

VM: Jump-vm = Allow RDP, Private IP: 192.168.3.4

VirtualAppliance-subnet = 192.168.4.0/24

VM: Demo-va = Allow RDP, Private IP: 192.168.4.4, NIC: IP Configuration --> IP Forwarding = Enable

**User Defined Route Table**: Demo-routeTable

**Routes**: Name: **ToBackendEndSubnet**; Prefix=192.168.2.0/24; Next Hop=Virtual Appliance, Next Hop IP: 192.168.4.4

**Subnets**: Frontend-subnet

RDP to all VMs, Go to Powershell and execute following cmdLet:

```
C:\> Powershell
PS: C:\> New-NetFirewallRule –DisplayName “Allow ICMPv4-In” –Protocol ICMPv4
```

In Virtual Appliance (Demo-va) execute following command:

```
C:\> Powershell
PS: C:\> Set-ItemProperty -Path HKLM:\SYSTEM\CurrentControlSet\Services\Tcpip\Parameters -Name IpEnableRouter -Value 1
```

Restart the Virtual Appliance VM

RDP to DemoFE-vm and execute the following command and note the Hop includes 192.168.4.4

```
C:\> tracert 192.168.2.4
```

RDP to DemoBE-vm and execute the following command and note the Hop doesnt include 192.168.4.4

```
PS: C:\> tracert 192.168.1.4
```

**Configure an application rule**

This is the application rule that allows outbound access to www.google.com.

1. In Vnet Create a Subnet by name=**"AzureFirewallSubnet" (DON’T change the name)**
2. **Create a Firewall** resource (Demo-firewall) in existing VNet (Demo-VNet) and with New IP Address (Demo-firewall-ip)
3. Create a Route with prefix 0.0.0.0/0 and for Next hop select Virtual Appliance and provide the Private IP Address of Firewall (192.168.5.4).
4. Goto to any and browse www.google.com.

Note that the request is **blocked** by the firewall

5. **Configure an Application Rule**: Source Address = <IP Range of Frontend-subnet> (192.168.1.0/24), Protocol=http, https; Target FQDNS=www.google.com

Note that the request is **not blocked** by the firewall

### Configure a network rule

This is the network rule that allows outbound access to two IP addresses at port 53 (DNS).

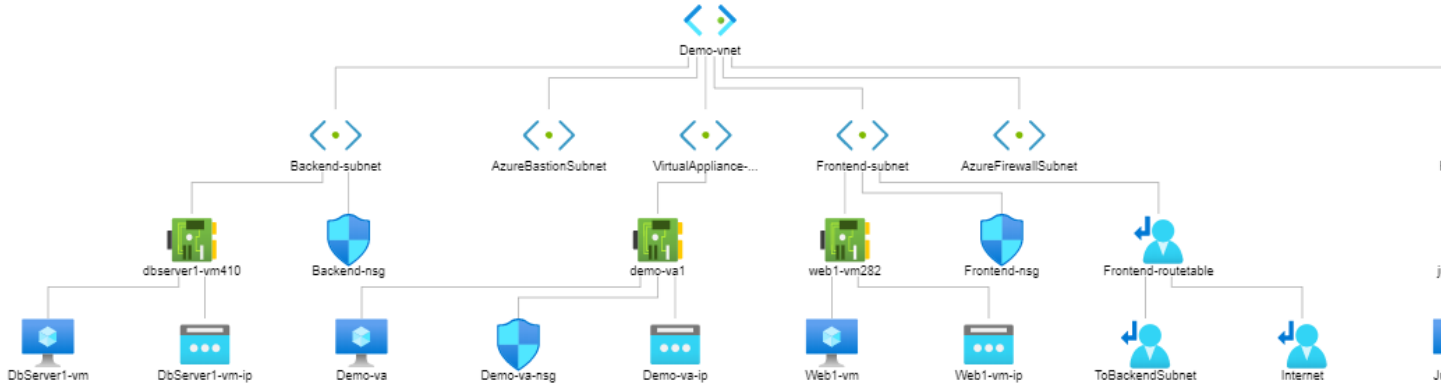
1. **Configure Network Rule**: Allow-DNS, Protocol=**UDP**, Source Address=<IP Range of Frontendsubnet>, Destination Address="209.244.0.3, 209.244.0.4", Destination Port=**53**
2. Change the DNS Settings of Virtual Network : Demo-vnet → DNS Servers → Add 209.244.0.3 & 209.244.0.4 as Servers
3. Restart the VM's

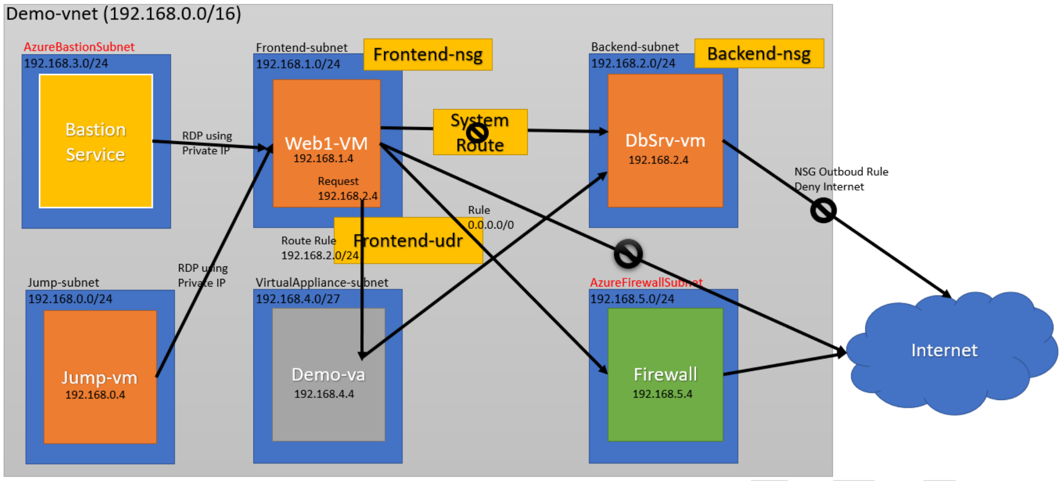
### Configure a DNAT rule

This rule allows you to **connect a remote desktop** to the virtual machine through the firewall.

1. Select the NAT rule collection tab → Add NAT rule collection.
2. Name=rdp, Priority=200,
3. Rules Name=rdp-nat, Protocol=TCP, Source type=IP address, Source=*, Destination address=<**firewall public IP address**>, Destination Ports=3389, Translated address=<**private IP address of VM**>, Translated port=3389.
4. Select Add.

## Summary of Task Done





1. Demo-vnet (192.168.0.0/16)

2. Frontend-subnet (192.168.1.0/24)

3. Backend-subnet (192.168.2.0/24)

4. Web1-vm (192.168.1.4)

5. DbSrv-vm (192.168.2.4)

6. Frontend-nsg Associated to Frontend-subnet

    a) Allow Inbound RDP(3389) and HTTP(80)

7. Backend-nsg Associated to Backend-subnet

    b) Allow Inbound RDP(3389) & SQL(1433)

    c) Deny Outbound Internet

8. AzureBastionSubnet (Subnet)

    Bastion Service to connect to all VM

9. VirtualAppliance-subnet (192.168.4.0/27)

10. Demo-va (192.168.4.4)

11. Frontend-udr and attach to Frontend-subnet

    Dest is 192.168.2.0/24 => Next Hop = VA

12. AzureFirewallSubnet (192.168.5.0/24)

13. Azure Firewall Service (192.168.5.4)

    Application Rule

      Allow *.google.com / *.deccansoft.com

    Network Rule

      Allow 8.8.8.8:53

14. New Rule Frontend-udr

Dest is 0.0.0.0/0 => Next Hop = 192.168.5.4 (Firewall)

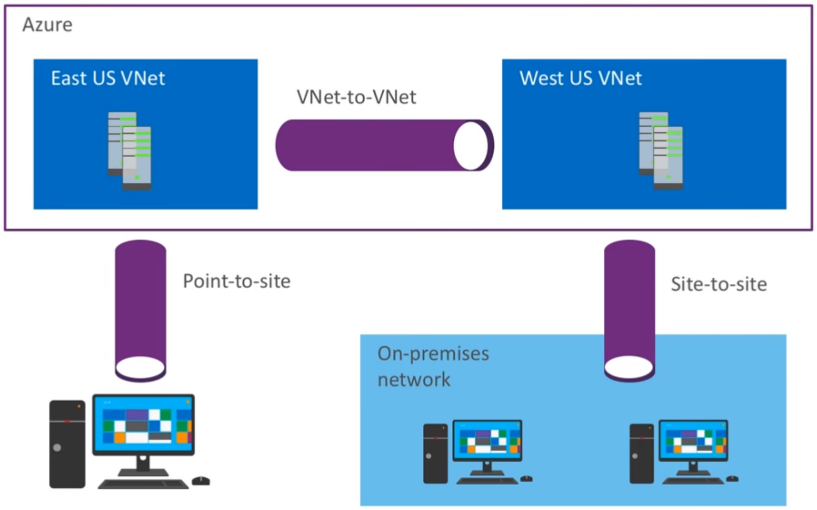
15. Jump-subnet (192.168.0.0/24)

Jump-vm (192.168.0.4)

With NSG and allowed RDP.

## 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.

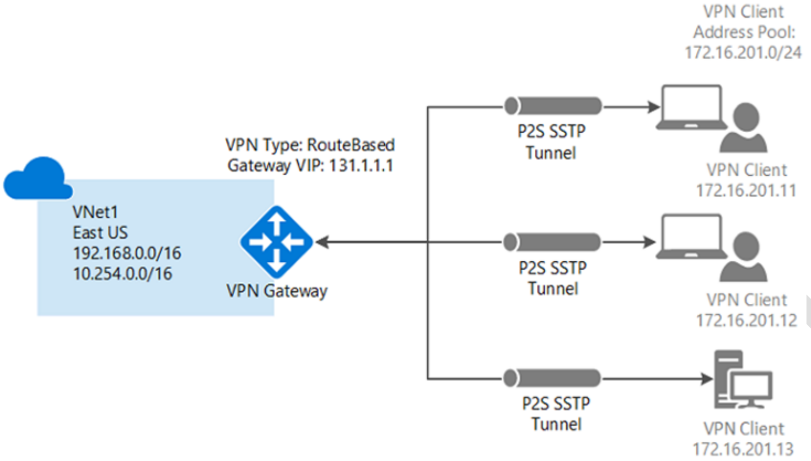
### VNet peering

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

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

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")
```

3. **To obtain the public key (.cer file) of Root Certificate**
    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

More about Certficates:

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

**Optional: 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 |

**About BGP with Azure VPN Gateway**

BGP (Border Gateway Protocol) is the standard routing protocol commonly used in the Internet to exchange routing and reachability information between two or more networks. When used in the context of Azure Virtual Networks, BGP enables the Azure VPN Gateways and your on-premises VPN devices, called BGP peers or neighbors, to exchange "routes" that will inform both gateways on the availability and reachability for those prefixes to go through the gateways or routers involved.

**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 and SSTP (SSL)**
    3. **Root Certificates**: Name=RootCert1, Public Certficate Data <Value copied in step 6>

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

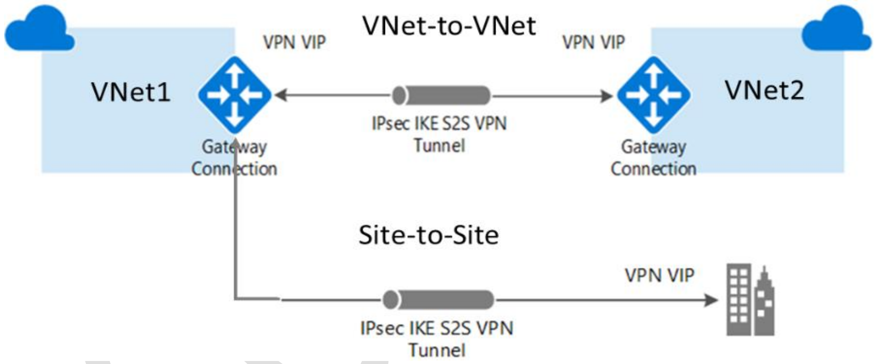
**Download and Install VPN client**

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 using VPN Gateway

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.

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.

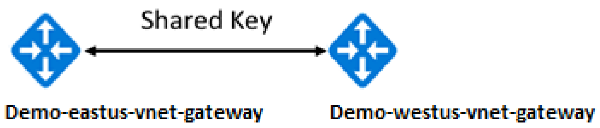
In the example, the virtual networks are in the same subscription, but in different resource groups. If your VNets are in different subscriptions, you can't create the connection in the portal. You can use PowerShell or CLI.

1. Create and configure the first VNet: **Demo-eastus-vnet**
2. Create a Gateway Subnet
3. Create a virtual network gateway – **Demo-eastus-vnet-gateway**

4. Create and configure the second VNet **Demo-westus-vnet**
5. Create a Gateway Subnet
6. Create a virtual network gateway – **Demo-westus-vnet-gateway**

**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 **Demo-eastus-vnet-gateway** connection
   - Select **Demo-eastus-vnet-gateway** → Connections → +Add
   - Name = EastToWestConnection
   - Connection type = VNet-to-VNet
   - Second virtual network gateway = **Demo-westus-vnet-gateway**
   - **Shared key = "abc123"**
8. Configure the **Demo-westus-vnet-gateway** connection
   Follow the steps from the previous section, replacing the values to create a connection from **Demo-eastus-vnet** to **Demo-westus-vnet**. 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**.
10. **You can also RDP (using Public IP) to one of the VM and RDP or browse websites (using Private IP) 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 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 (Even if flow is disabled)
13. Cannot use overlapping address spaces.

**Pricing:**

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

**Configuring a 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.

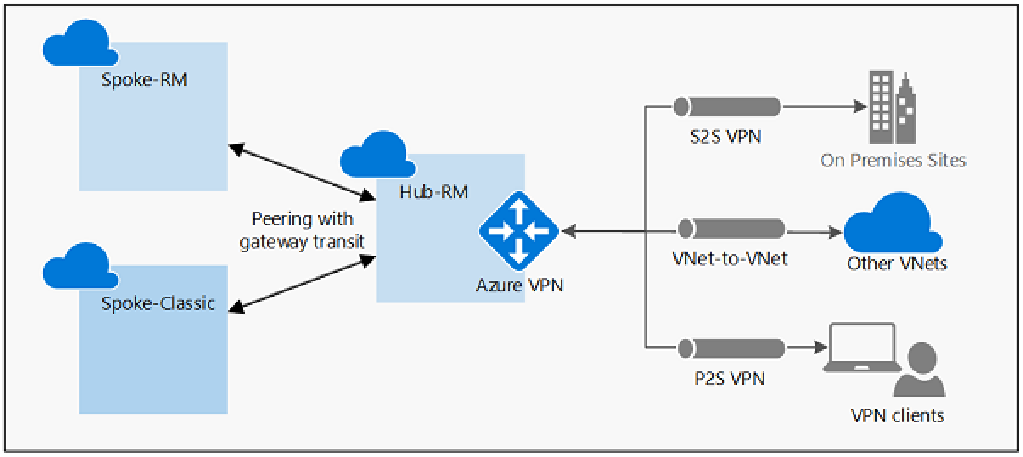
  If you don't have read access to the virtual network or subscription you want to peer with, check this box.

- **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.

**Configure VPN gateway transit for virtual network peering**



In the diagram, gateway transit allows the peered virtual networks to use the Azure VPN gateway in Hub-RM. Connectivity available on the VPN gateway, including S2S, P2S, and VNet-to-VNet connections, applies to all three virtual networks.

In HubToSpoke VNet Peering – Select **Use this virtual network's gateway**

In SpokeToHub VNet Peering - Select **Use the remote virtual network's gateway**

**Now, we can connect from our Local Machine (Provided P2S Connection is established to Hub) to a VM in Hub as well as Spoke VNet.**

**Note: Delete the existing VPN Client. Download new VPN Client and setup again.**

**Communication between spokes: https://blog.ine.com/azure-practical-peer-to-peer-transitive-routing**

## Using PowerShell Commands

1. Create a new resource group

```
New-AzResourceGroup -Name TestRG -Location centralus
```

2. Create a new VNet named *TestVNet*

```
New-AzVirtualNetwork -ResourceGroupName TestRG -Name TestVNet -AddressPrefix 192.168.0.0/16 -Location centralus
```

3. Store the virtual network object in a variable

```
$vnet = Get-AzVirtualNetwork -ResourceGroupName TestRG -Name TestVNet
```

4. Add a subnet to the new VNet variable

```
Add-AzVirtualNetworkSubnetConfig -Name FrontEndSubnet -VirtualNetwork $vnet -AddressPrefix 192.168.1.0/24
```

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

```
Add-AzVirtualNetworkSubnetConfig -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-AzVirtualNetwork -VirtualNetwork $vnet
```

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

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