Microsoft Azure: Infrastructure as a Service (IaaS)

Module 4: IaaS Virtual Networking

Azure Networking

Microsoft Azure Virtual Networks

- Your virtual branch office/data center in the cloud
  - Allows customers to extend their Enterprise Networks into Microsoft Azure
  - Networking on-ramp for migrating existing apps and services to Microsoft Azure
  - Allows customers to run hybrid apps that span the cloud and their on-premises setup
- A protected private virtual network in the cloud
  - Allows customers to set up secure private IPv4 networks fully contained within Microsoft Azure
  - IP address persistence capability
  - Inter-service (Dynamic IP address) DIP-to-DIP communication ~ PaaS/IaaS communication

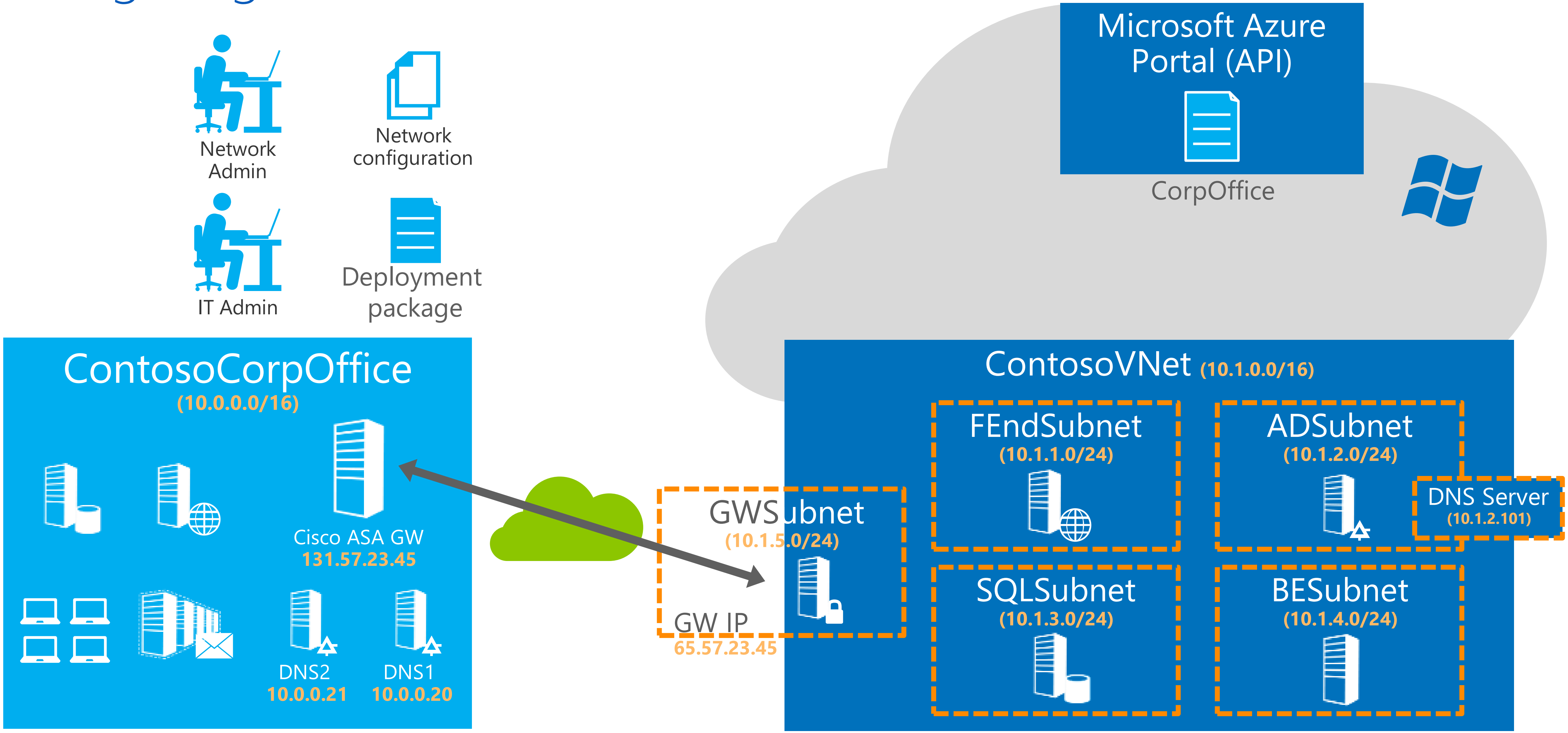
Virtual Network Features

- Customer-managed private virtual networks within Microsoft Azure
  - “Bring your own IPv4 addresses”
  - Provides control over placement of Microsoft Azure VMs and roles within the network
  - Stable IPv4 addresses for VMs
- Hosted VPN Gateway that enables site-to-site connectivity
  - Automated provisioning and management
  - Support existing on-premises VPN devices
- Use on-premises DNS servers for name resolution or Azure DNS
  - Allows you to use your own on-premises DNS servers for name resolution
  - Allows VMs running in Microsoft Azure to be joined to corporate domains running on-premises (use your on-premises Active Directory)
- Can provide internal static IP addresses (via PowerShell) [DIP]
- Can provide public reserved IP addresses (via PowerShell) [VIP]
- Multiple virtual IP addresses per Cloud Service (classic) or per VM (V2) [ILPIP]

How to Setup Virtual Networks

- Portal
  - Wizard to create, and update virtual networks
  - Manage Gateway Lifecycle
- APIs and Scripting
  - REST APIs
  - PowerShell cmdlets
  - Network Configuration
- Operations on Network Configuration
  - Set Network Configuration
  - Get Network Configuration
- Azure Resource Manager (ARM) scripting/deployment

Configuring Virtual Networks



Demonstration: Deploying a Virtual Network

Module 4: IaaS Virtual Networking

Azure Connectivity

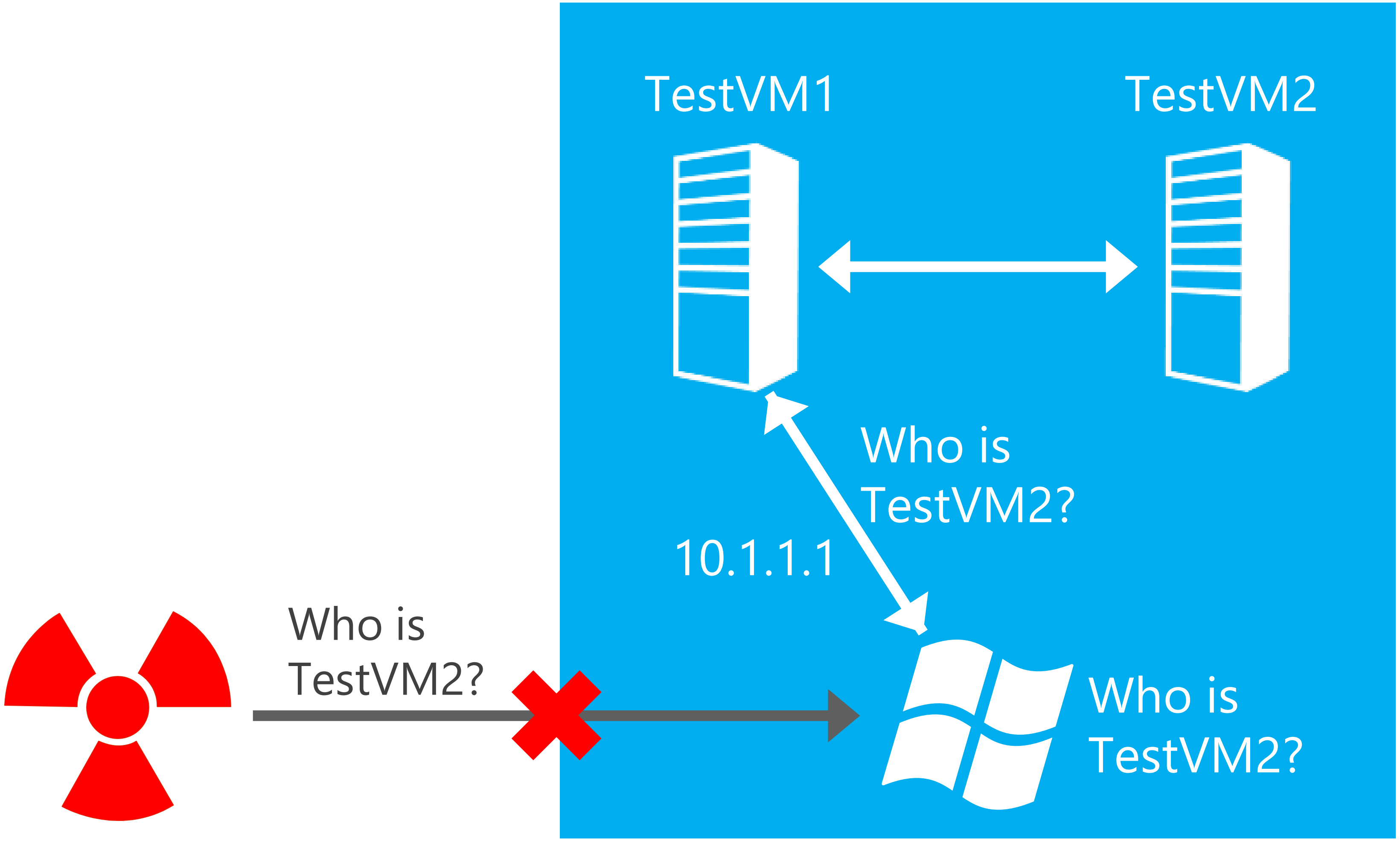
Glossary for Network basic components

- VIP (Virtual IP address)
  - A public IP address belongs to the cloud service. It also serves as an Azure Load Balancer which tells how network traffic should be directed before being routed to the VM.
  - It is possible to reserve an IP from the Microsoft pool
- DIP (Dynamic IP address):
  - An internal IP assigned by Microsoft Azure DHCP to the VM
  - Associated automatically with the VM when created
  - It is released when VM is deleted or deallocated (default)
  - It is possible to configure and static IP address
  - You can have more than one DIP per VM (Multi-NIC support)
- ILPIP (Instance Level Public IP)
  - A ILPIP is associated with the VM in addition to the VIP. Traffic to the ILPIP goes directly to the VM and is not routed through the Azure Load Balancer

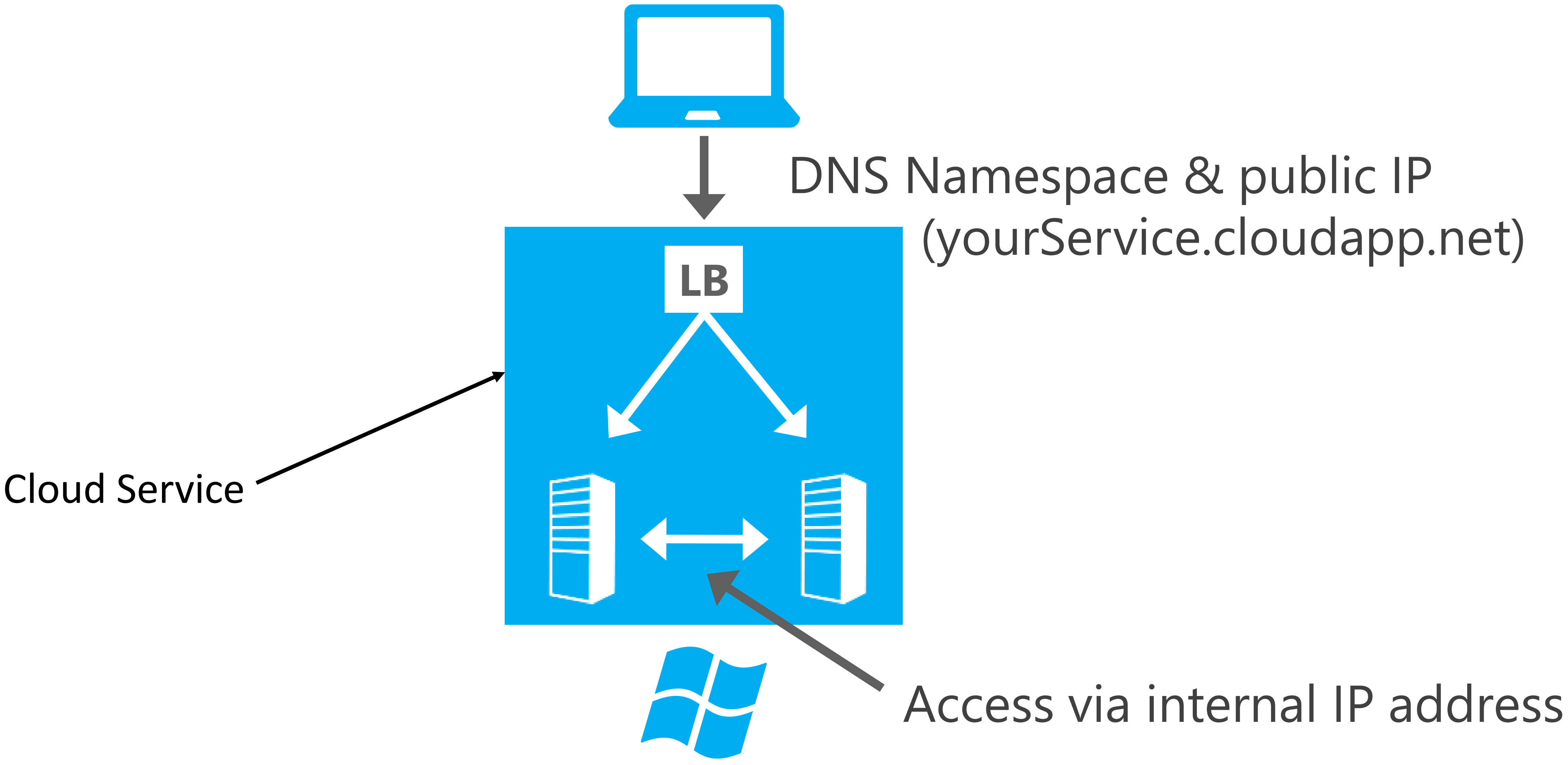
Glossary for Network basic components (con't)

- Azure Load Balancer (External LB)
  - All inbound traffic to the VIP is routed through the ELB which firewalls and distributes it. Allows only inbound TCP or UDP traffic. This is a software load balancer (SLB)
- Internal Load Balancer (ILB):
  - It is configured to port-forward or load-balance traffic inside a VNET or cloud service to different VMs.
- Endpoint (Classic)
  - Associates a VIP/DIP + port combination on a VM with a port on either the Azure Load Balancer for public-facing traffic or the Internal Load Balancer for traffic inside a VNET (or cloud service).
- Inbound Security Rule (V2)
  - Associated with a network security group. Associates a VIP/DIP + port combination on a VM with a port on either the Azure Load Balancer for public-facing traffic or the Internal Load Balancer for traffic inside a VNET

Microsoft Azure Provided DNS – Within a Cloud Service (Classic)



Overview: Basic Connectivity in Microsoft Azure (Classic)

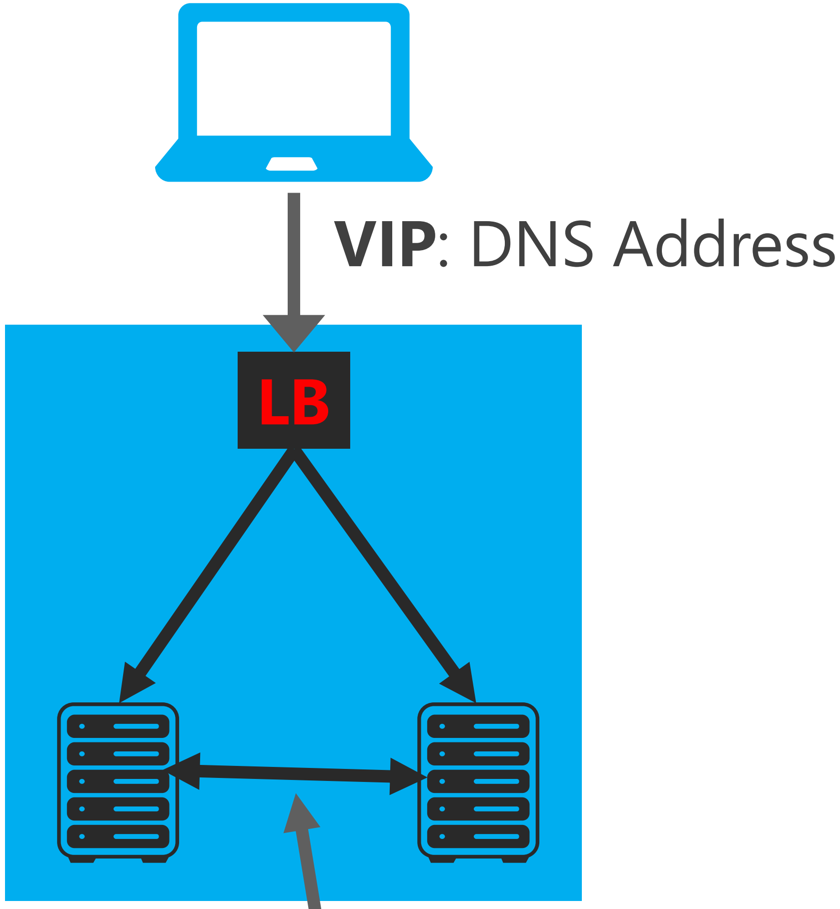


DNS Namespace & public IP (yourService.cloudapp.net)

Cloud Service

Access via internal IP address

Overview: Existing Connectivity in Microsoft Azure (Classic)



Internal IP Addresses

foo.cloudapp.net → **VIP**

DNS Address

- Load balanced endpoint. Stable VIP per service deployment
- Single port per endpoint with protocols HTTP, HTTPS, TCP
- Each individual VM can reserve a separate public IP address

Internal IP Addresses

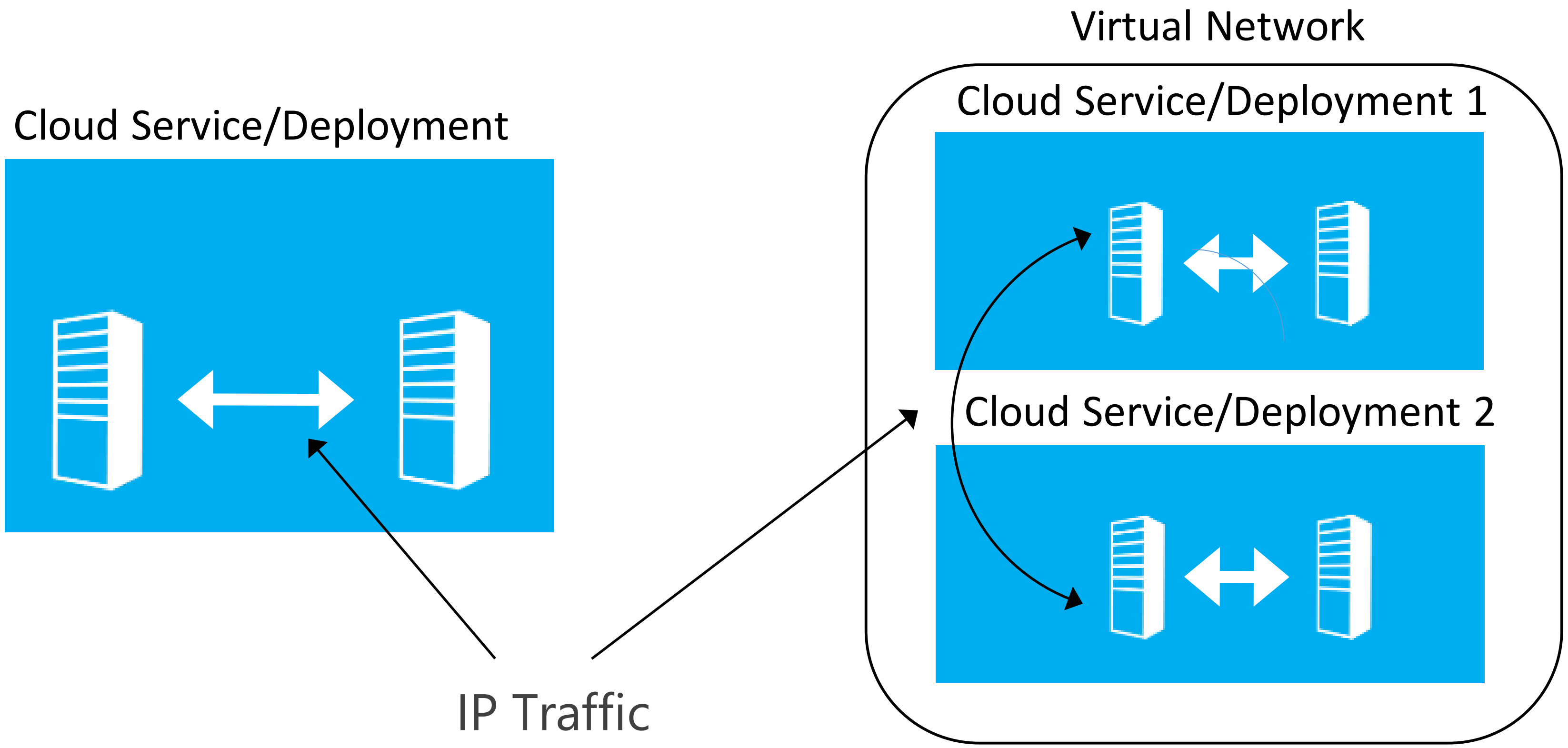
- Instance-to-instance communication in Cloud Service
- Supported Protocols: TCP
- Port ranges supported
- Communication boundary = Deployment boundary

Name Resolution

- Microsoft Azure-provided DNS service for Cloud service-level name resolution

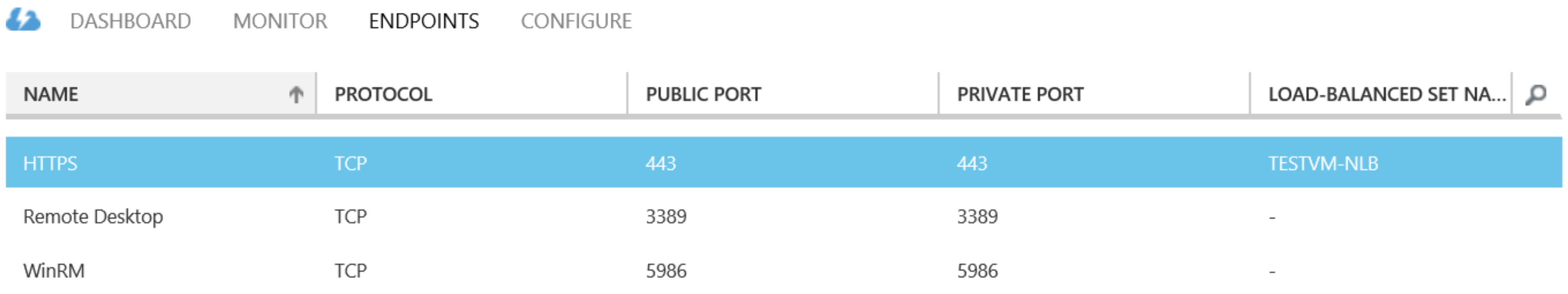
Internal IP Addresses (Classic)

- Open by default with VMs (Firewalls are not)
- Allows all IP traffic to flow
- Open ICMPv4 port to ping
- Can be used across Cloud Services within a single virtual network



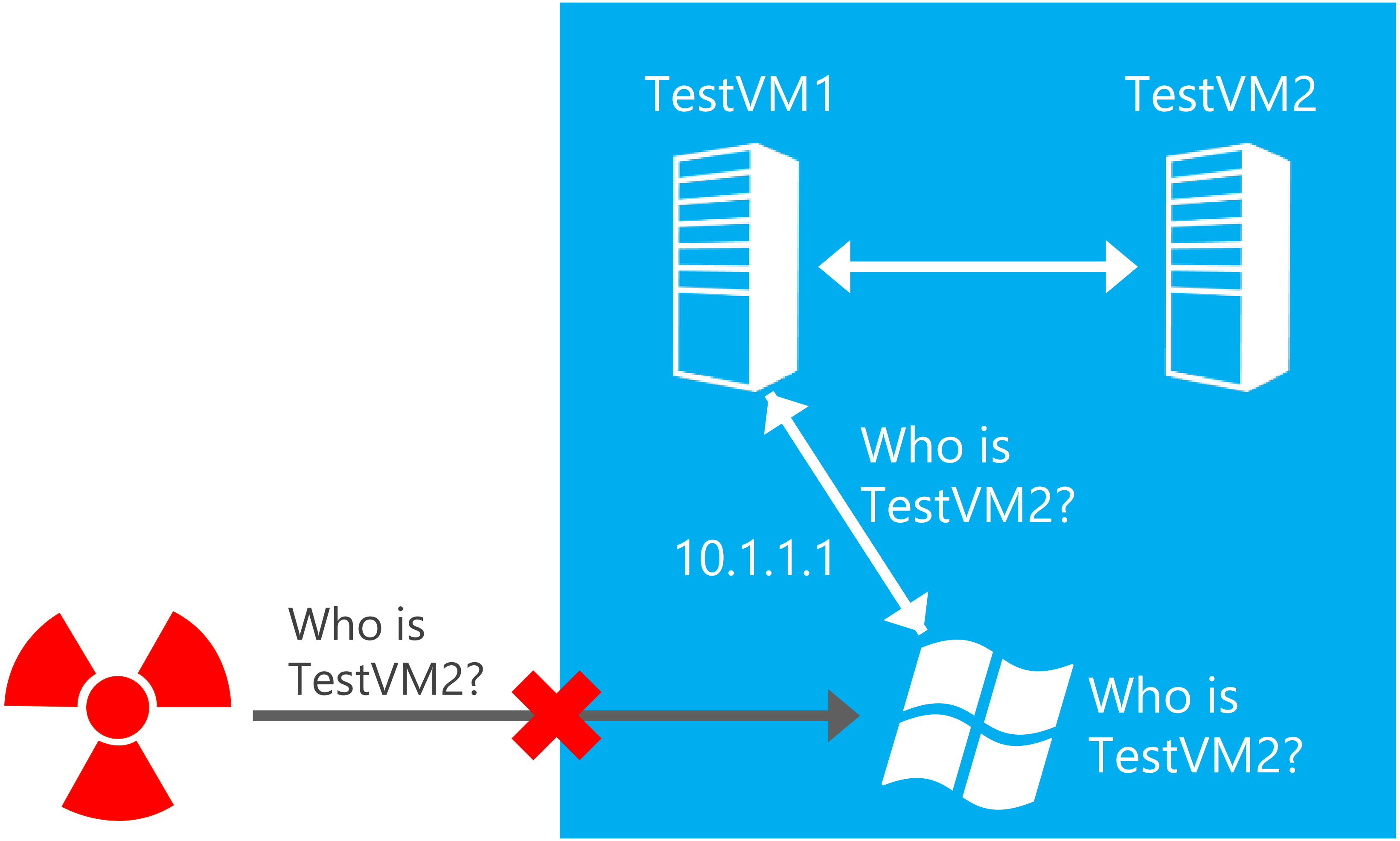
Virtual Machine Endpoints (Classic)

- VMs can automatically communicate with other VMs in the same cloud service or virtual network
- Endpoints are required to direct Internet or other virtual networks inbound network traffic to a VM
- In the Azure Management Portal, endpoints are automatically created for:
  - Remote Desktop
  - Windows PowerShell Remoting
  - Secure Shell (SSH)
- Each endpoint has a public port and a private port:
  - Public port: used by the Azure load balancer to listen for incoming traffic to the VM from the Internet
  - Private port: used by the VM to listen for incoming traffic to an application or service running on the VM
- ACLs on an endpoint can restrict traffic based upon source IP address
  - Rules can allow or deny traffic from specific IPs and known IP address ranges
  - Rules are evaluated in order starting with the first rule and ending with the last rule
    - Rules should be ordered from least restrictive to most restrictive
  - If the virtual machine is in an Azure VNet, use Network Security Groups instead

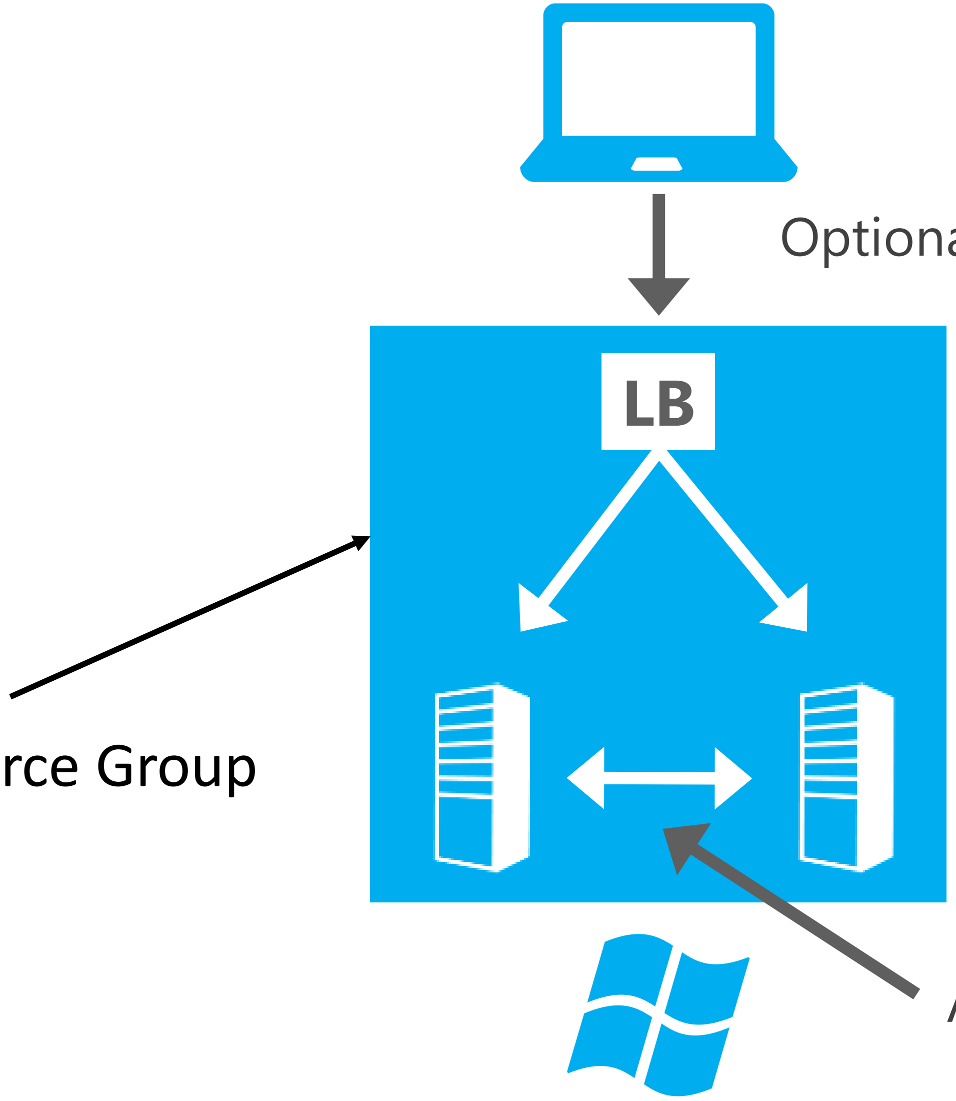


NAME	PROTOCOL	PUBLIC PORT	PRIVATE PORT	LOAD-BALANCED SET NA...
HTTPS	TCP	443	443	TESTVM-NLB
Remote Desktop	TCP	3389	3389	-
WinRM	TCP	5986	5986	-

Microsoft Azure Provided DNS – Within a Virtual Network (V2)



Overview: Basic Connectivity in Microsoft Azure (V2)

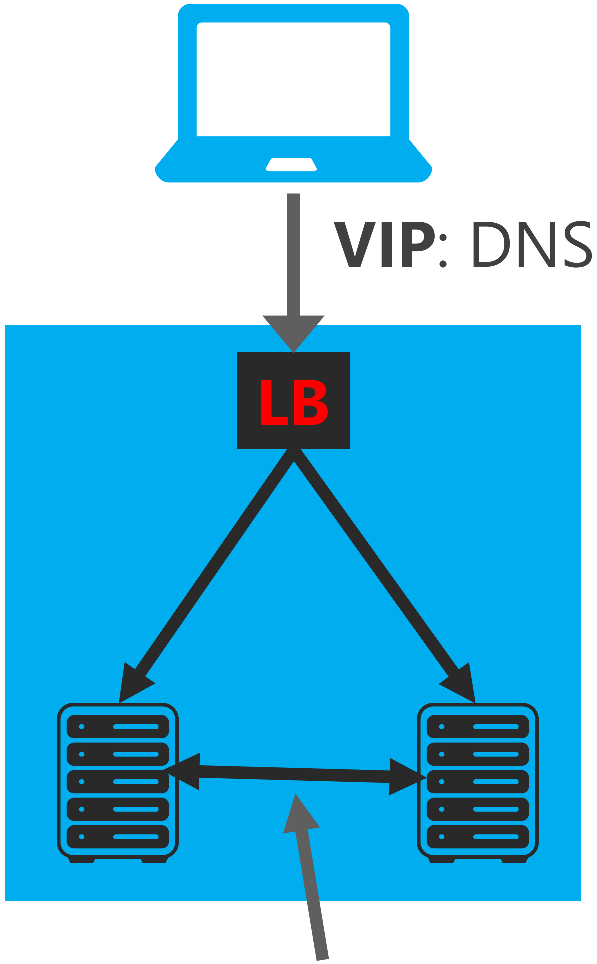


Optional DNS Namespace & public IP
(yourDNSname.region.cloudapp.azure.com)

VNet in Resource Group

Access via internal IP address – same VNet

Overview: Existing Connectivity in Microsoft Azure (V2)



VIP: DNS Address

Internal IP Addresses

DNS Address

- Optional load balanced endpoint. Stable VIP per service deployment. You can choose not to have a VIP
- Single port per inbound security rule with protocols HTTP, HTTPS, TCP

Internal IP Addresses

- Instance-to-instance communication in same VNet
- Supported Protocols: TCP
- Port ranges supported
- Communication boundary = Deployment boundary

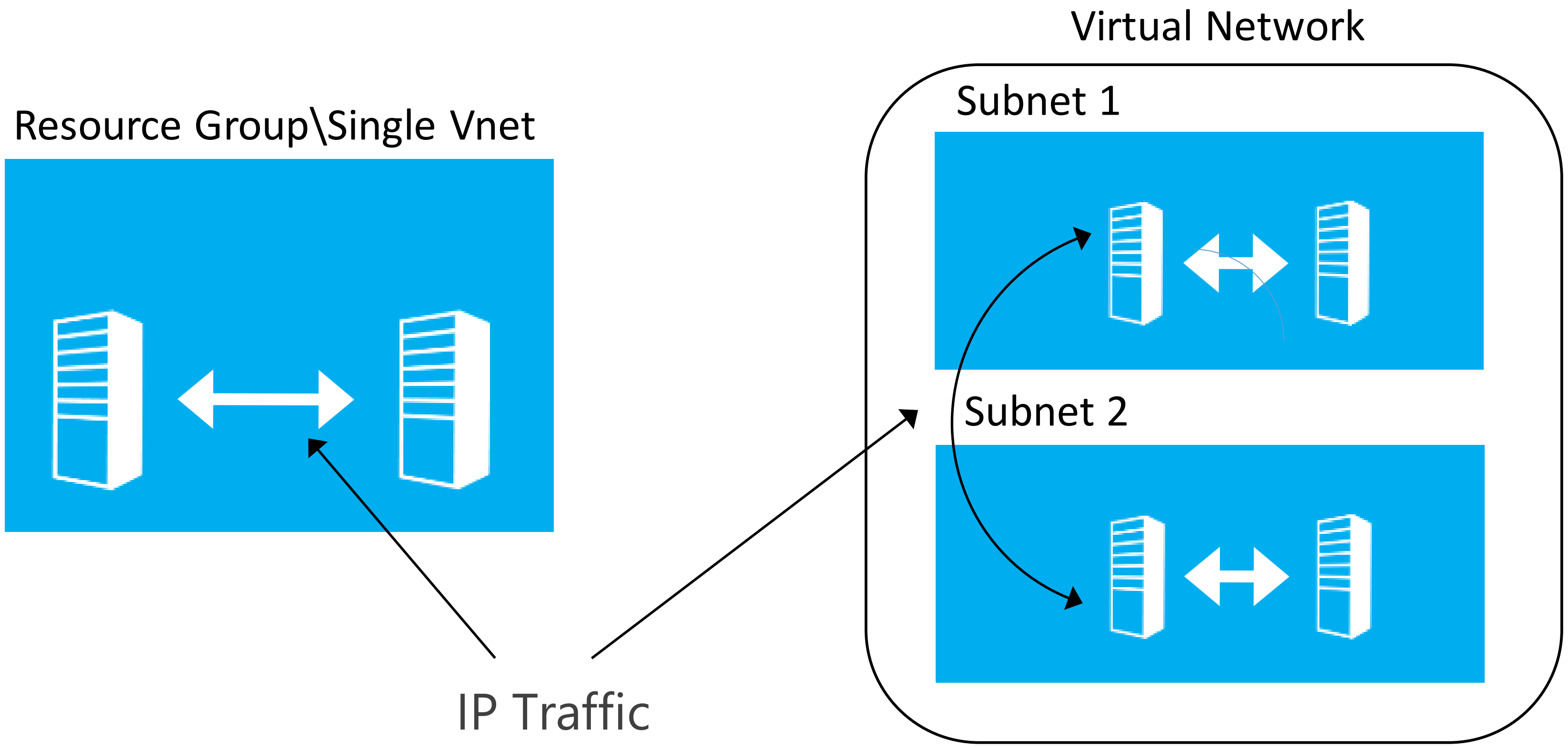
Name Resolution

- Microsoft Azure-provided DNS service for VMs in the same virtual network/resource group

Dnsname.region.cloudapp.azure.com → **VIP**

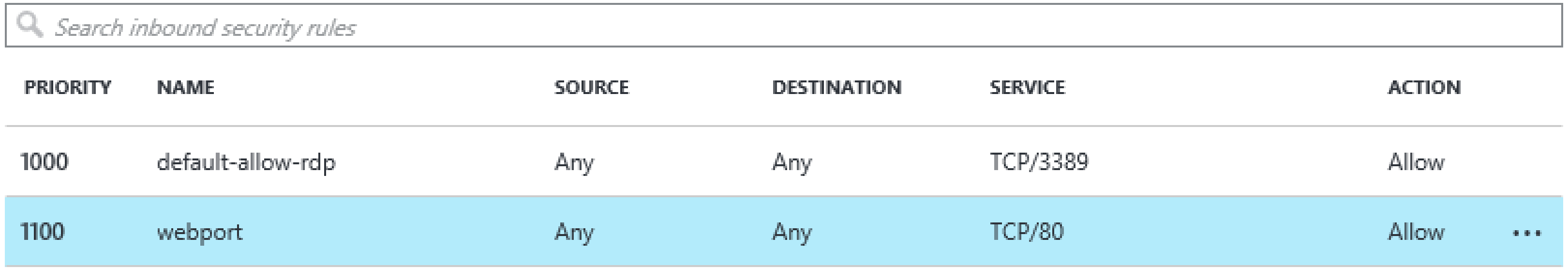
Internal IP Addresses (V2)

- Open by default with VMs (Firewalls are not)
- Allows all IP traffic to flow
- Open ICMPv4 port to ping
- Can be used across VMs within a single virtual network



Virtual Machine Inbound Security Rules (V2)

- VMs can automatically communicate with other VMs in the same virtual network
- Inbound security rules are required to direct Internet or other virtual networks inbound network traffic to a VM
- In the Azure Management Portal, endpoints are automatically created for:
  - Remote Desktop
- Each inbound security rule has a source and destination port range:
  - Source port range: used by the Azure to listen for incoming traffic to the VM
  - Destination port range: used by the VM to listen for incoming traffic to an application or service running on the VM
- ACLs on an endpoint can restrict traffic based upon source IP address range
  - Inbound or outbound security rules can allow or deny traffic from specific IPs and known IP address ranges
  - Rules are evaluated based on priority number. The lower the number, the higher the priority
  - Inbound and Outbound Security rules are part of a Network Security group

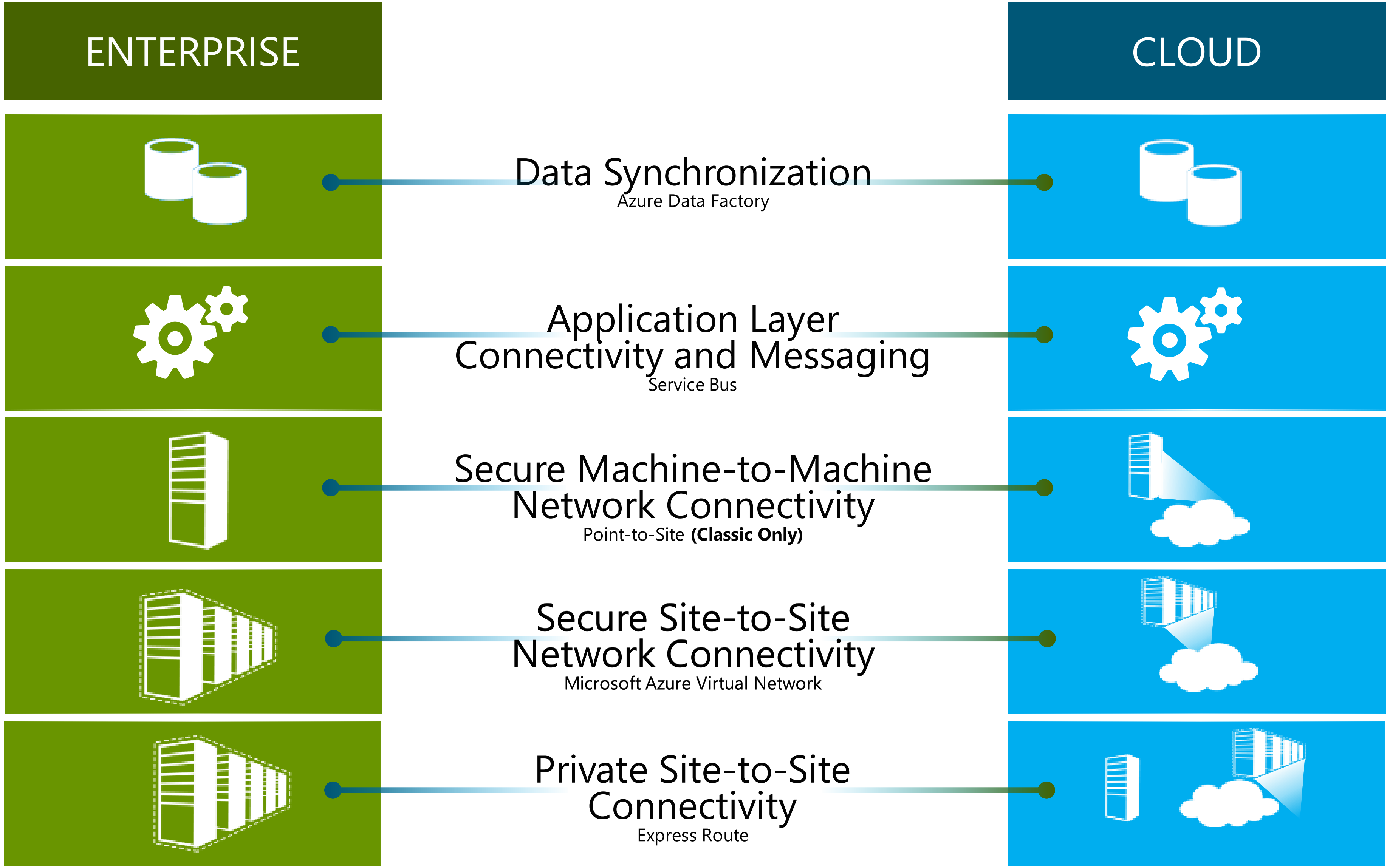


PRIORITY	NAME	SOURCE	DESTINATION	SERVICE	ACTION	
1000	default-allow-rdp	Any	Any	TCP/3389	Allow	
1100	webport	Any	Any	TCP/80	Allow	•••

Classic and V2 Comparison

	Classic	V2
VM Container	Cloud Service	Resource Group + VNet
Region span	Single region	Multi-region
FQDN	Myapp.cloudapp.net	Optional - myDNS.region.cloudapp.azure.com
ILPIP	Optional - Supplied by Azure	Optional – supplied by Azure
VIP	Supplied by Azure	Optional – supplied by Azure
External Connectivity	Endpoints – RDP/SSH default	Inbound Security Rule – RDP by default
Virtual Network	Not required	Required
Azure DNS	Within Cloud Service	Within Virtual Network
API	REST / Azure Service Management	REST / Azure Resource Manager

Microsoft Azure External Connectivity Options



ENTERPRISE

CLOUD

Data Synchronization
Azure Data Factory

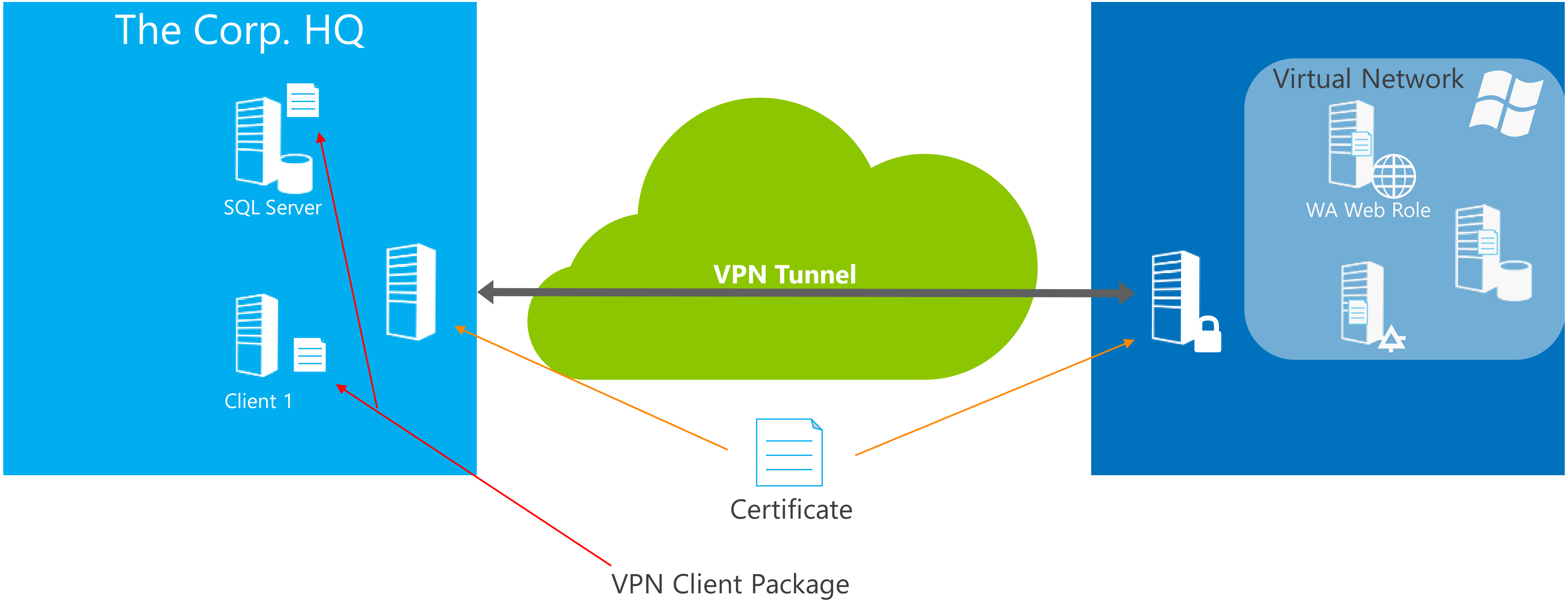
Application Layer Connectivity and Messaging
Service Bus

Secure Machine-to-Machine Network Connectivity
Point-to-Site **(Classic Only)**

Secure Site-to-Site Network Connectivity
Microsoft Azure Virtual Network

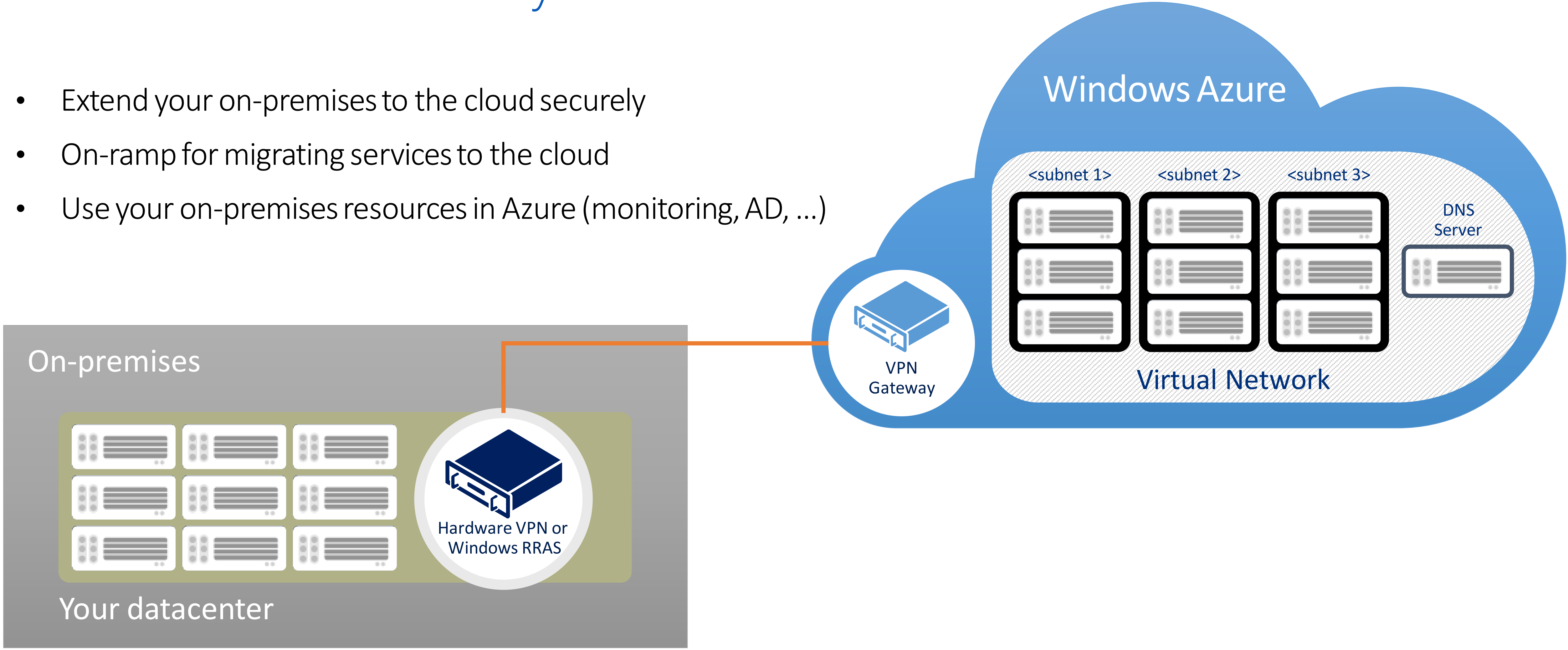
Private Site-to-Site Connectivity
Express Route

Point-to-Site

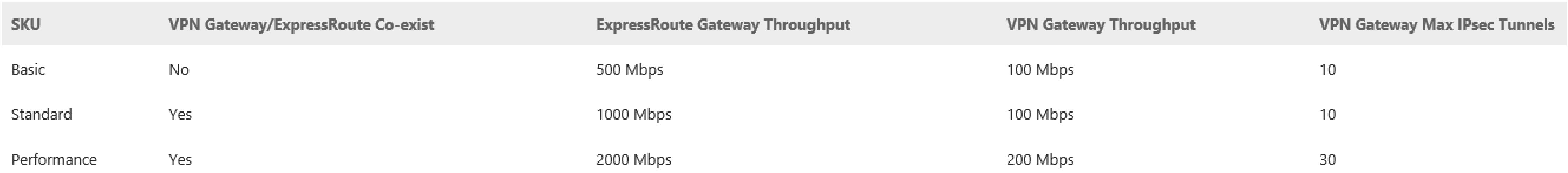


Site-to-Site Connectivity

- Extend your on-premises to the cloud securely
- On-ramp for migrating services to the cloud
- Use your on-premises resources in Azure (monitoring, AD, ...)

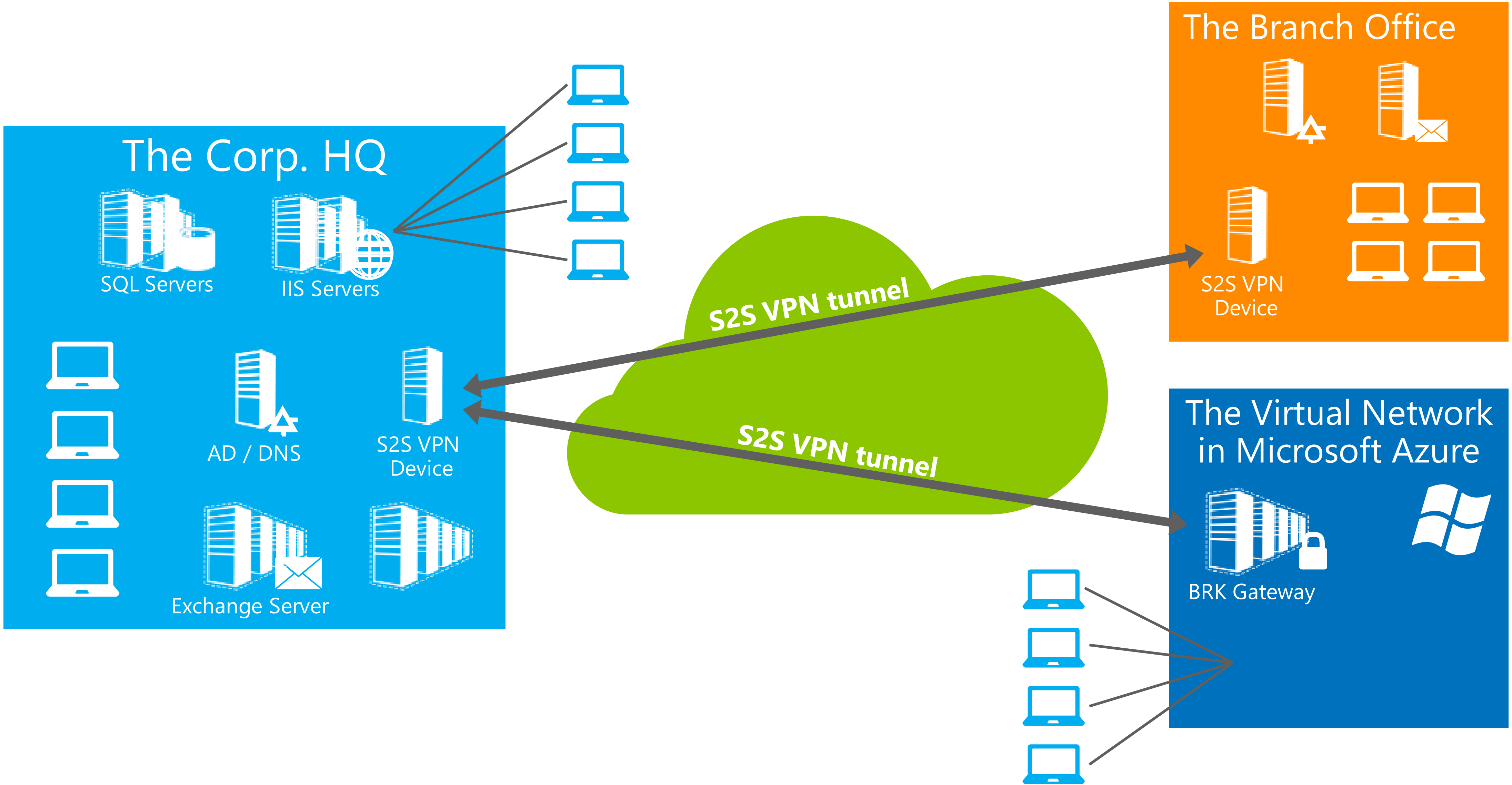


VPN Gateways



SKU	VPN Gateway/ExpressRoute Co-exist	ExpressRoute Gateway Throughput	VPN Gateway Throughput	VPN Gateway Max IPsec Tunnels
Basic	No	500 Mbps	100 Mbps	10
Standard	Yes	1000 Mbps	100 Mbps	10
Performance	Yes	2000 Mbps	200 Mbps	30

The Virtual Branch Office



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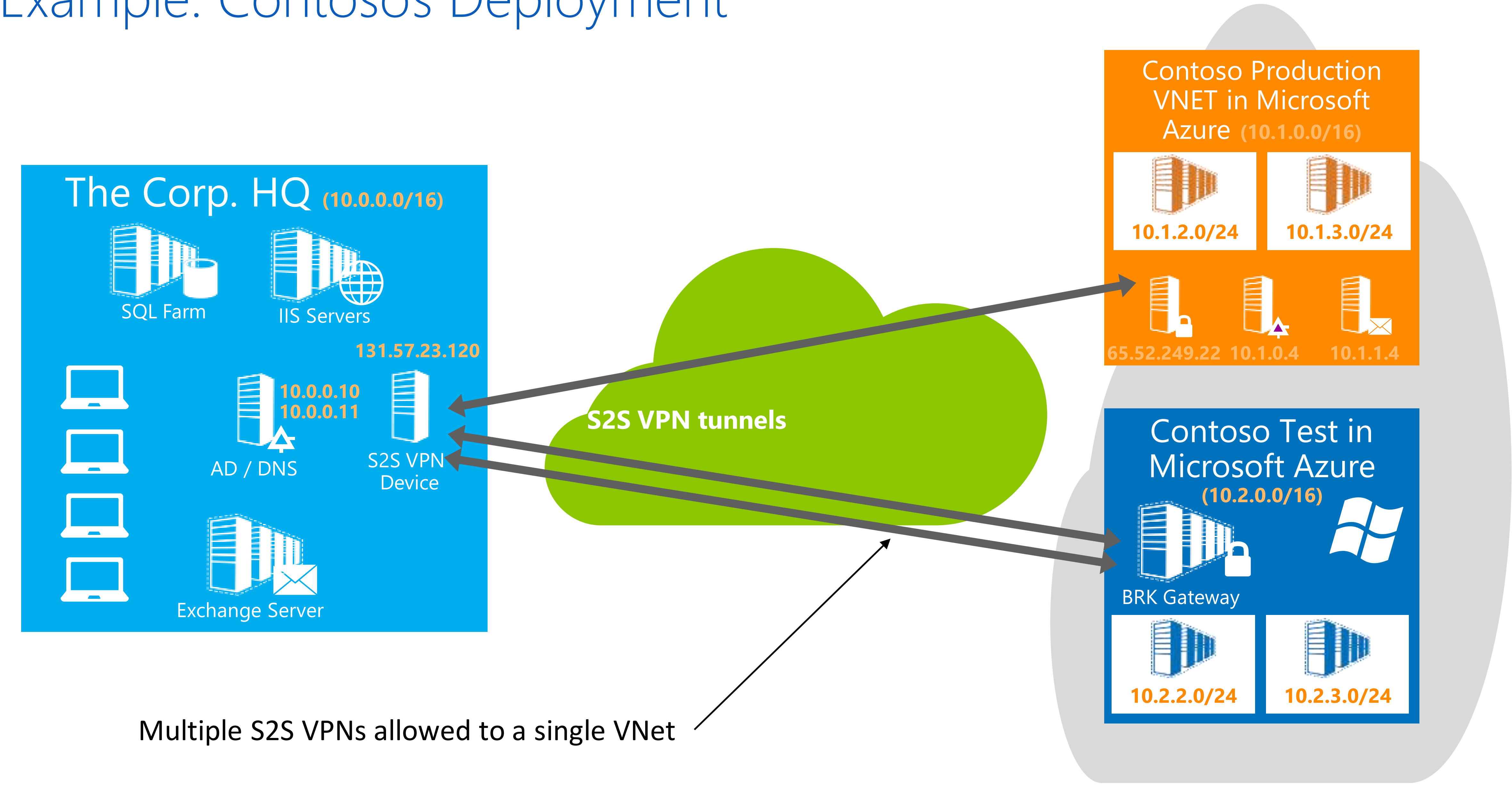
Multi-Site VPN

- Create a multi-site VPN in order to connect multiple on-premises sites to a single virtual network gateway
- Requires dynamic routing configured on the VNet gateway
  - Can change the gateway type without needing to rebuild the virtual network to accommodate multi-site
  - Need to ensure on-premises VPN gateway supports dynamic routing VPN.
- Add configuration settings to the network configuration file
- Changes to the VNet won’t be available through the Management Portal
  - Can use it for everything else except making configuration changes to this particular virtual network.

Example: Contoso's Deployment



Multiple S2S VPNs allowed to a single VNet

VNet to VNet Connectivity

- Cross region geo-redundancy and geo-presence
  - You can set up your own geo-replication or synchronization with secure connectivity without going over internet-facing endpoints
  - With Azure Load Balancer and Microsoft or third party clustering technologies, you can setup highly available workloads with geo-redundancy across multiple Azure regions
- Regional multi-tier applications with strong isolation boundary
  - Within the same region, you can setup multi-tier applications with multiple virtual networks connected together with strong isolation and secure inter-tier communication
- Cross subscription, inter-organization communication in Azure
  - Connect workloads from different subscriptions together securely between virtual networks
  - Enable cross organization communication with secure VPN technology within Azure.

What is ExpressRoute?

ExpressRoute provides organizations a private, dedicated, high-throughput network connection between Windows Azure datacenters and their on-premises IT environment.

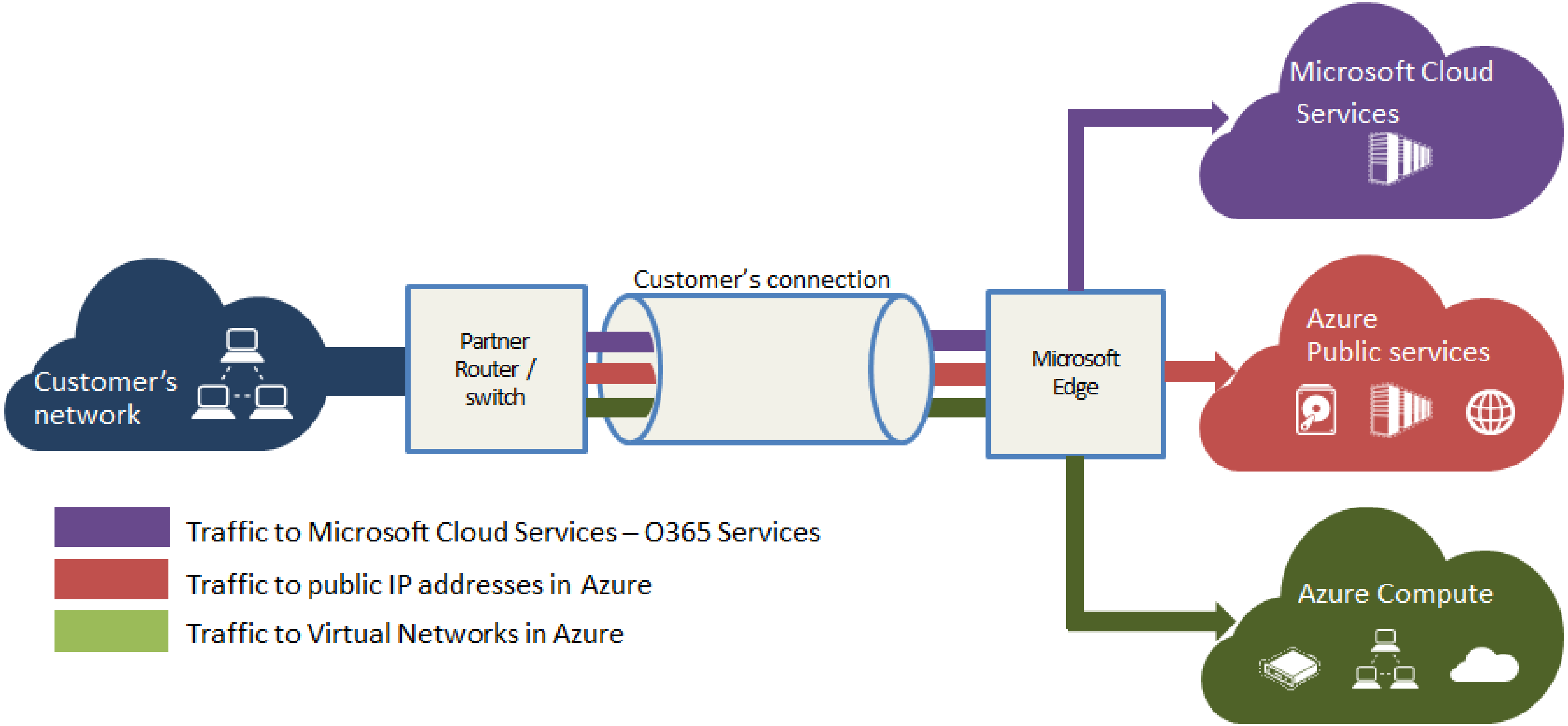
Predictable performance

Security

High throughput

Lower cost

ExpressRoute Peerings

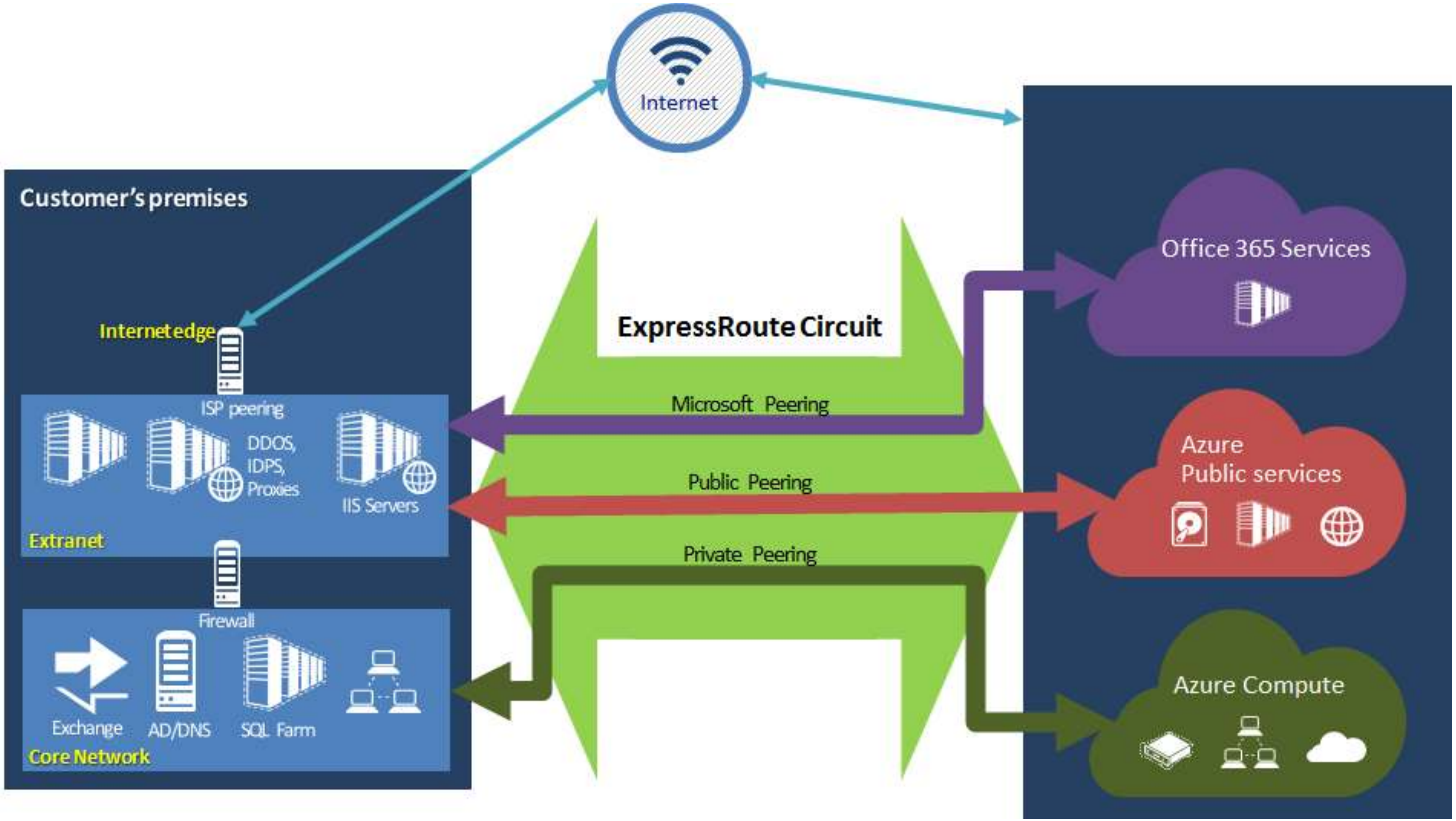


🟪 Traffic to Microsoft Cloud Services – O365 Services

🟥 Traffic to public IP addresses in Azure

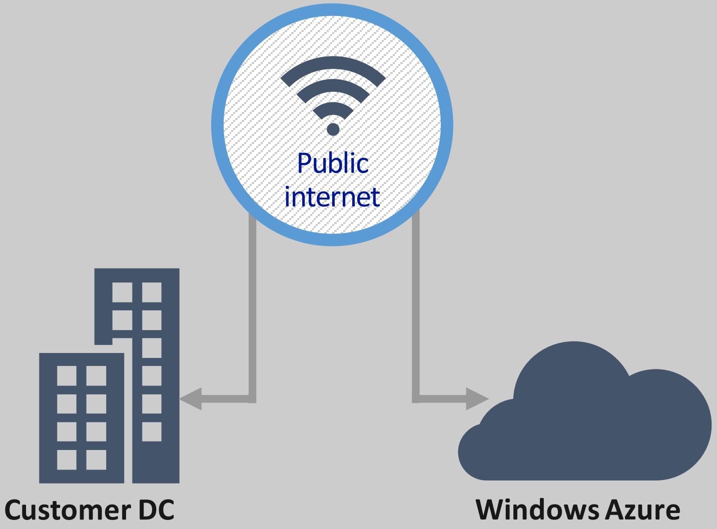
🟩 Traffic to Virtual Networks in Azure

Public, Private and Microsoft peering



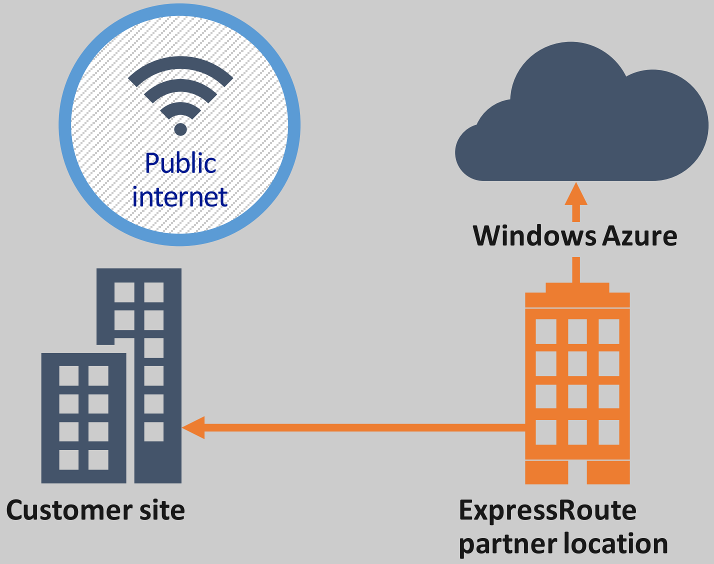
Virtual Network and ExpressRoute

Scenario 1: IPSec VPN over internet



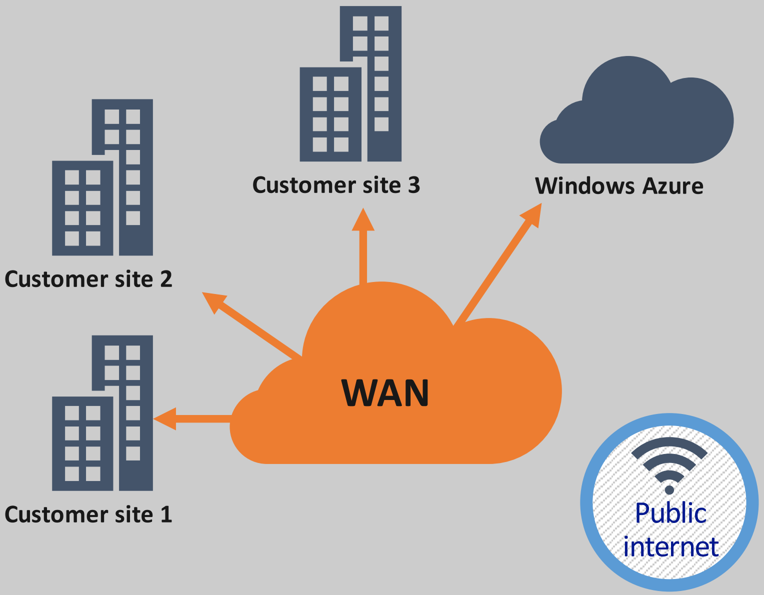
Connect via an encrypted link over public internet

Scenario 2: Exchange Provider



Peer at an ExpressRoute location, an Exchange Provider facility

Scenario 3: Network Service Provider



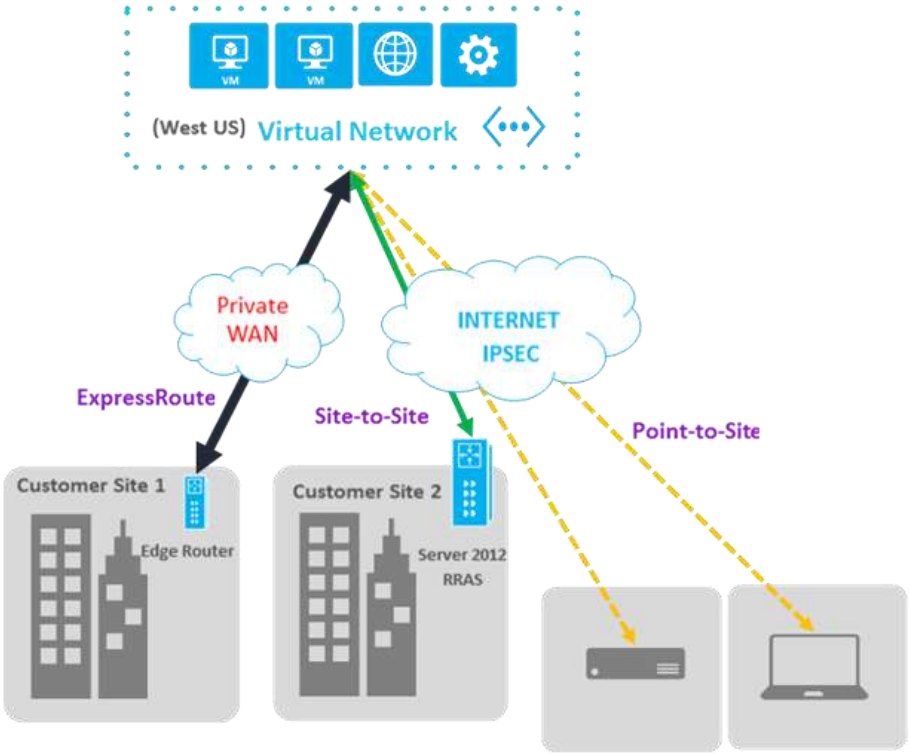
Connection from a WAN provided by Network Service Provider.
Azure becomes another site on the customer's WAN network.

Virtual Network - Compute only.

ExpressRoute - Provides customer choice and include access to compute, storage, and other Azure services.

VPN GW S2S and ExpressRoute coexistence

- VPN gateway allows you to have Site-to-Site (S2S) VPN connectivity to a Virtual Network that also has a gateway connected to an ExpressRoute circuit.
- This enables new connectivity scenarios:
  - You can now use S2S VPN tunnel as a backup for your ExpressRoute connection.
  - You can connect branch offices that aren’t part of your WAN to your Azure virtual networks that are also connected via ExpressRoute.
  - You can have Point-to-Site connections to the same Virtual Network that is also connected via ExpressRoute enabling dev/test and mobile worker scenarios.



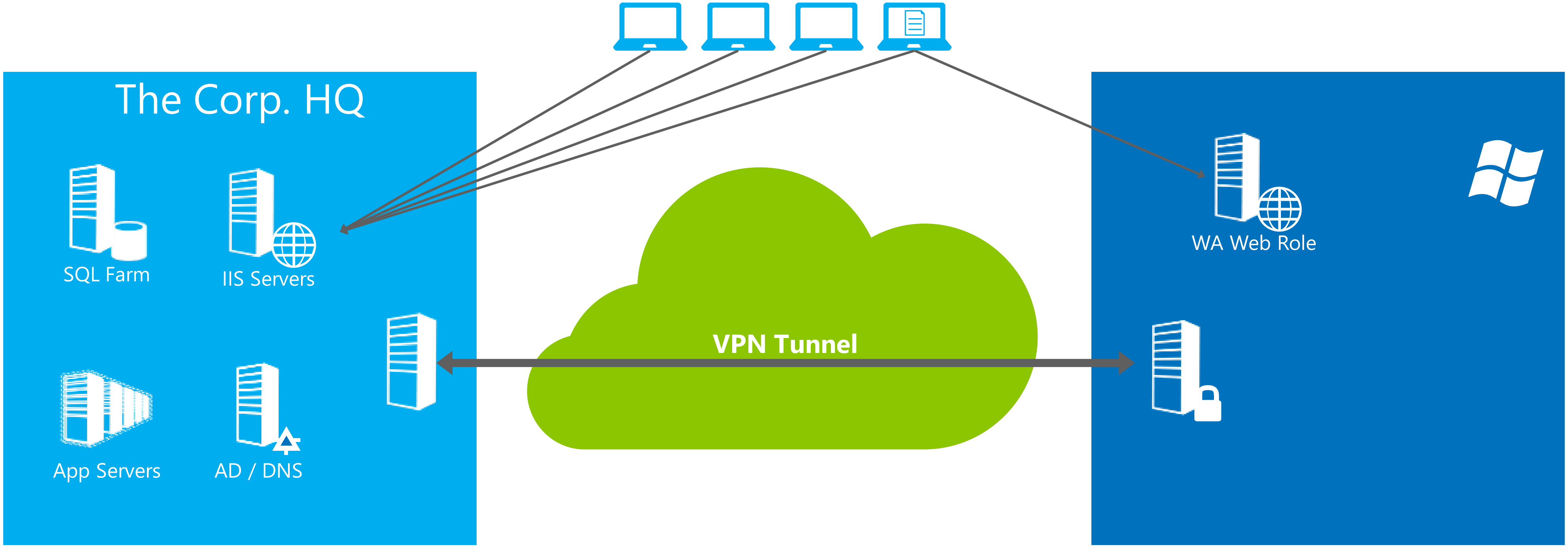
Module 4: IaaS Virtual Networking

Networking Scenarios

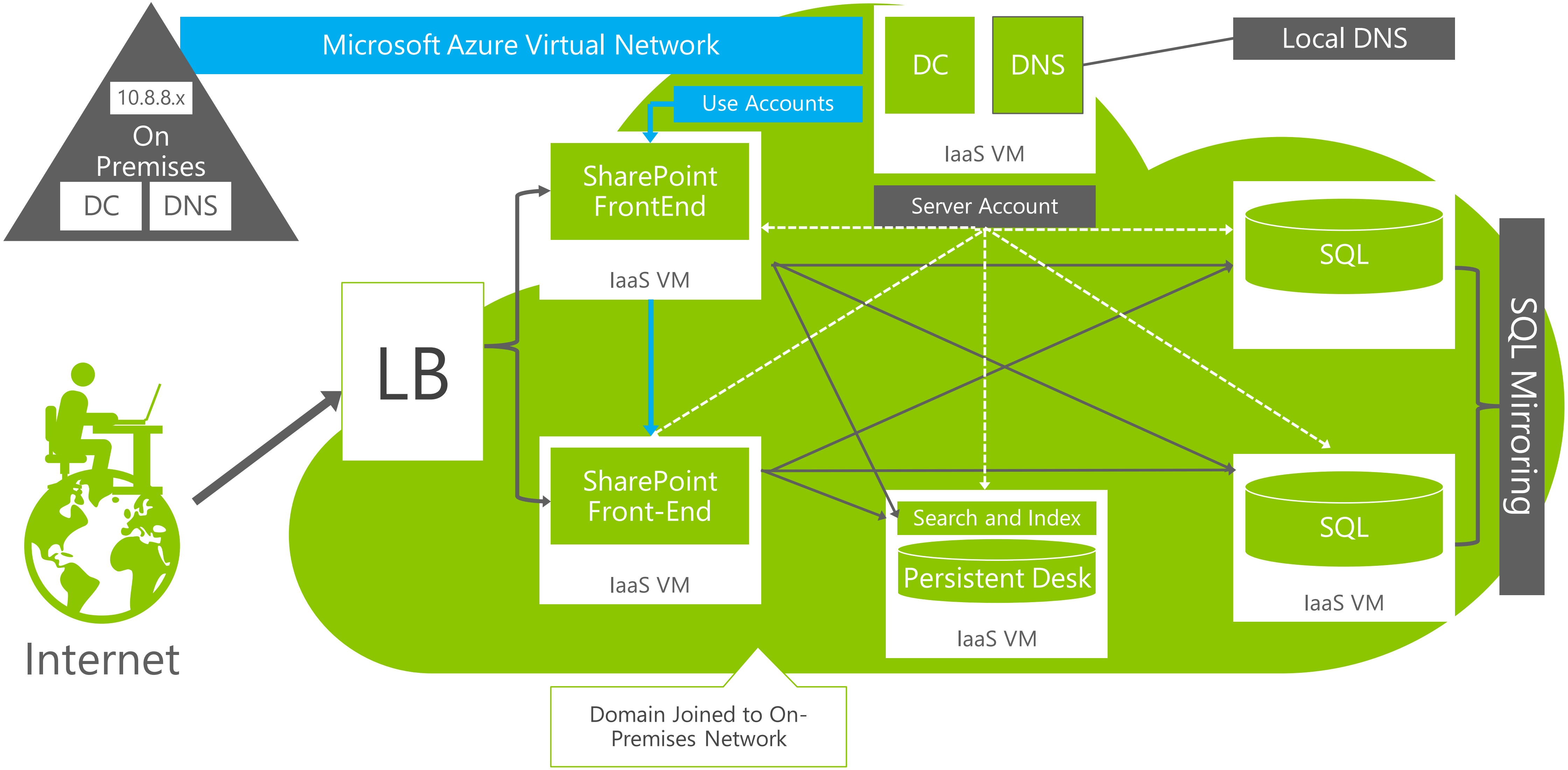
Virtual Network Scenarios

- Hybrid Public/Private Cloud
  - Enterprise app in Microsoft Azure requiring connectivity to on-premises resources
- Enterprise Identity and Access Control
  - Manage identity and access control with on-premises resources (on-premises Active Directory)
- Monitoring and Management
  - Remote monitoring and troubleshooting of resources running in Microsoft Azure (SCOM)
- Advanced Connectivity Requirements
  - Cloud deployments requiring persistent IP addresses and direct connectivity across services

Application Migration



SharePoint in Microsoft Azure



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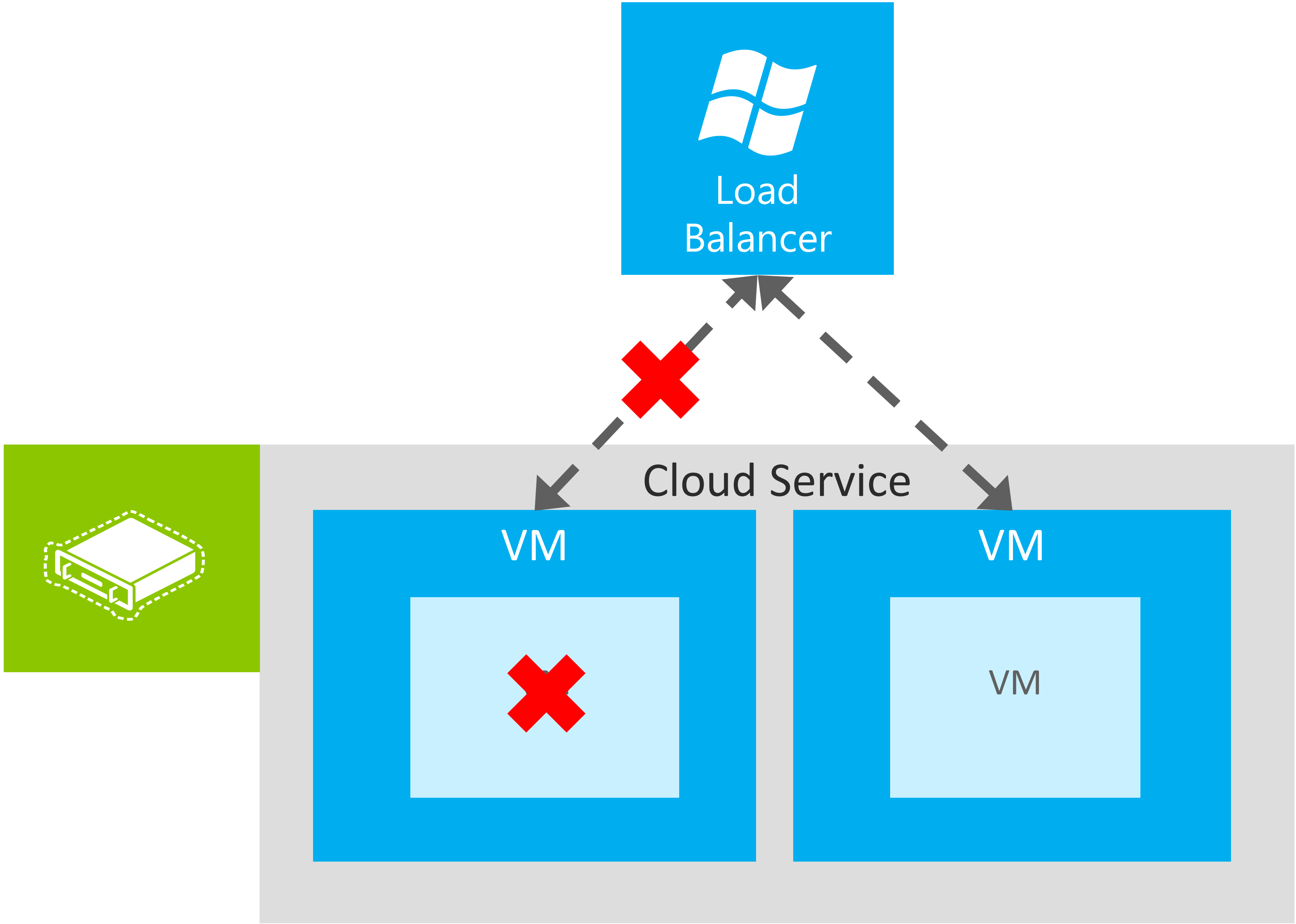
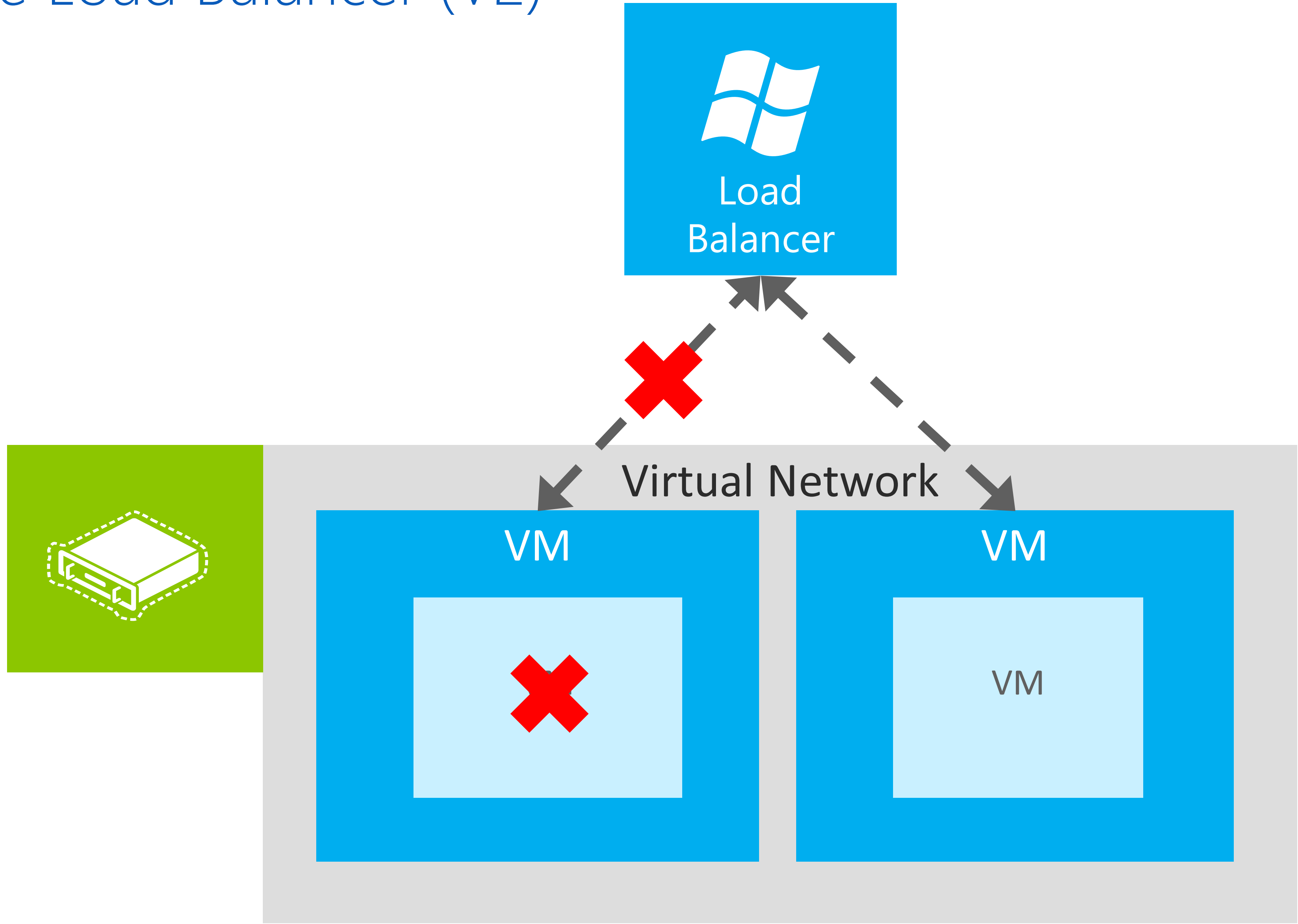
Module 4: IaaS Virtual Networking

High Availability

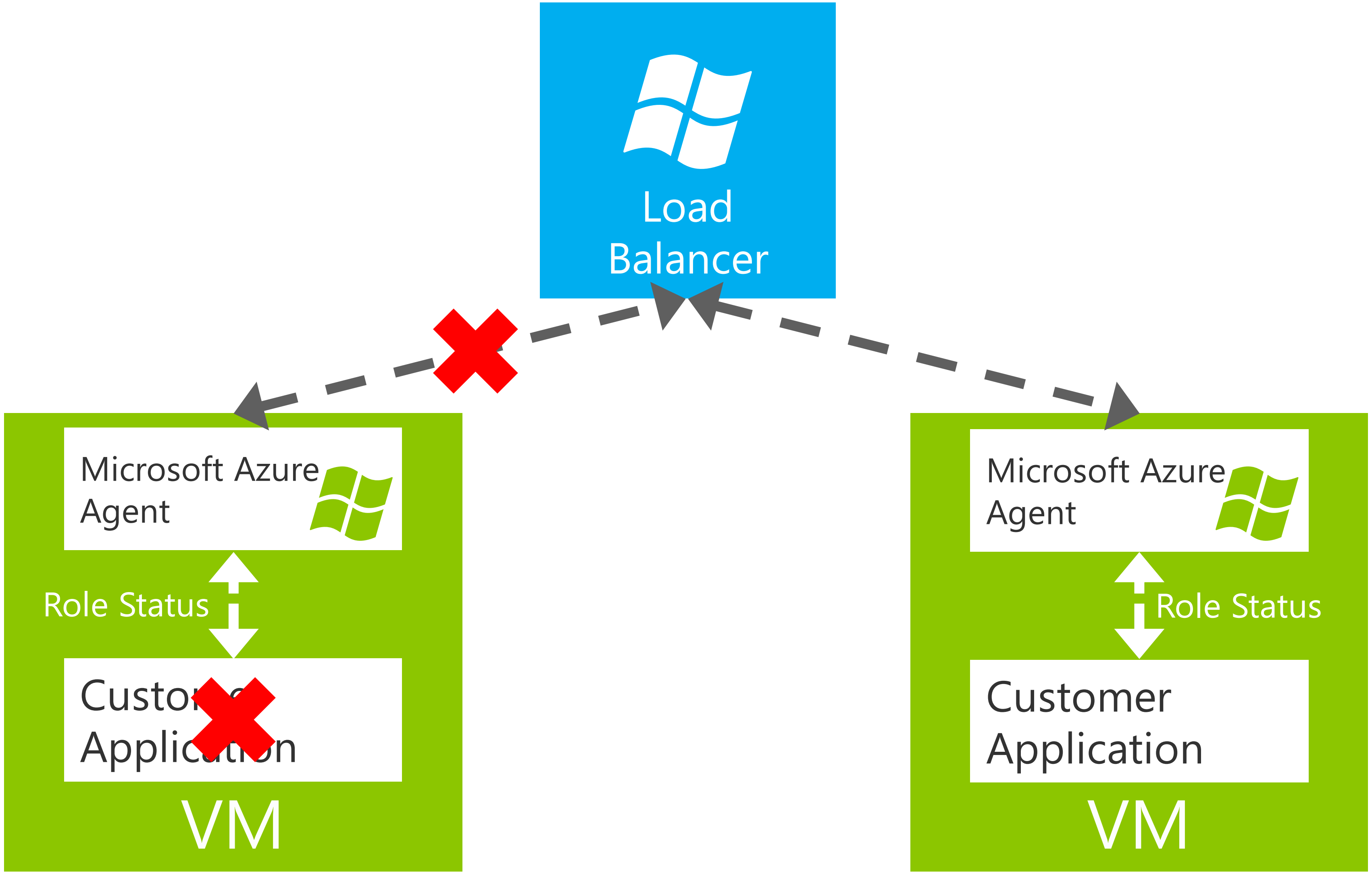
Azure Load Balancer (Classic)



Azure Load Balancer (V2)



Load Balancer: Default Health Probe for Load Balanced Sets



Load Balancer

Microsoft Azure Agent

Role Status

Customer Application

VM

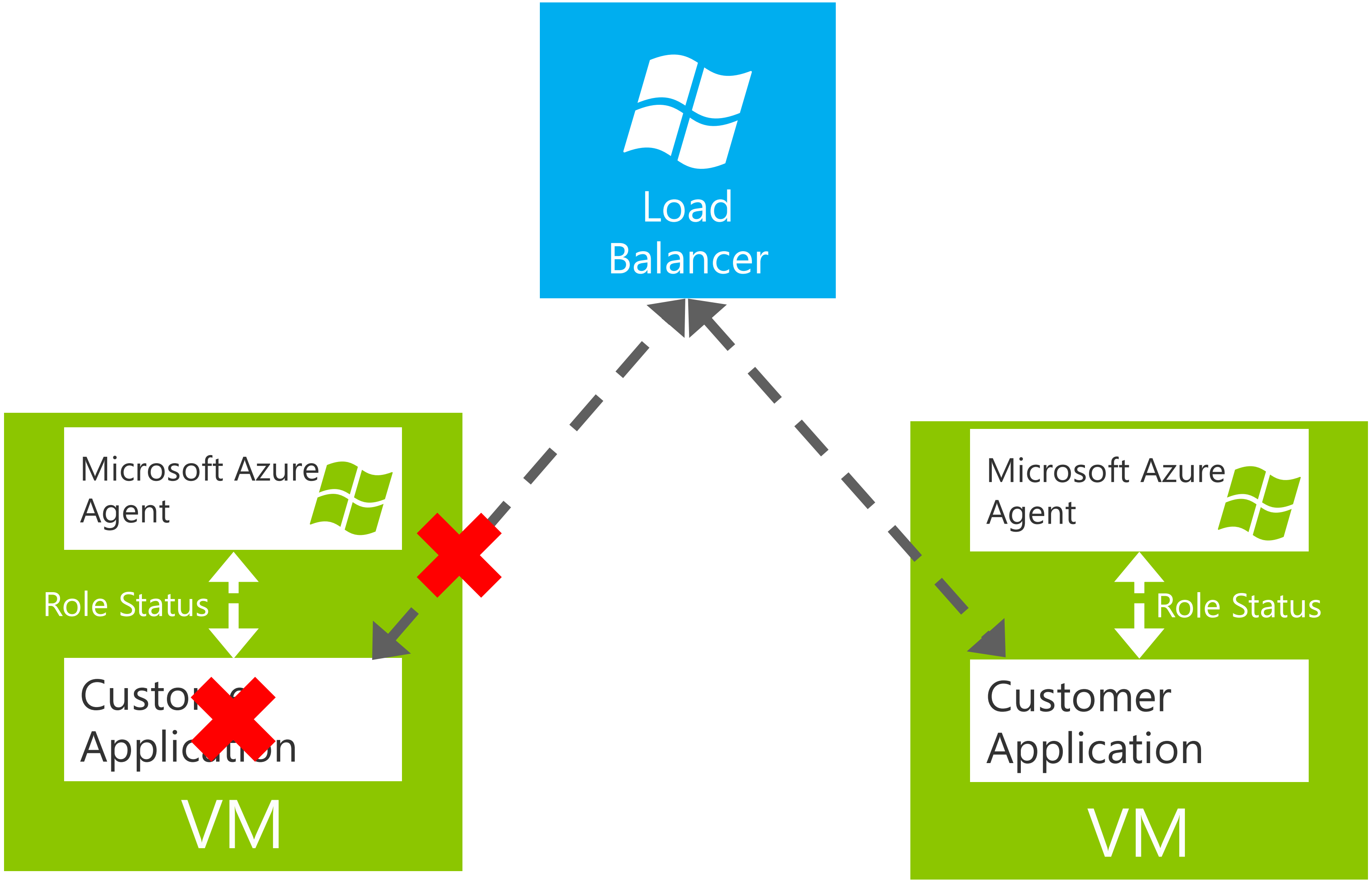
Microsoft Azure Agent

Role Status

Customer Application

VM

Load Balancer: Custom Health Probe for Load Balanced Sets

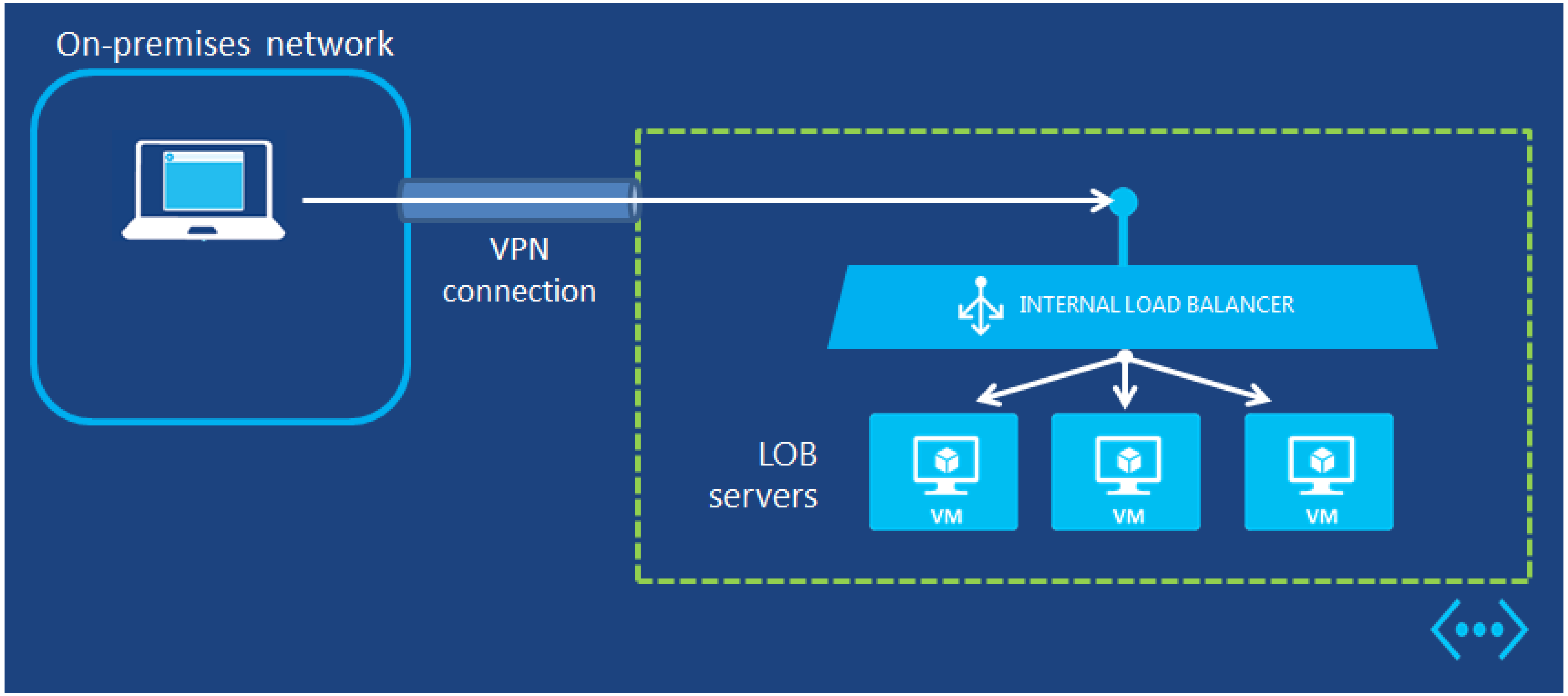


Azure Internal Load Balancer - ILB

- Provides load balancing for machines inside of a Cloud Service or Virtual network
  - Between virtual machines in the same Cloud Service (Classic)
  - Within a virtual network, from virtual machines in a virtual network to a set of virtual machines that reside within the same cloud service of the virtual network.
  - For a cross-premises virtual network, from on-premises computers to a set of virtual machines that reside within the same cloud service of the virtual network
  - Between virtual machines in a virtual network (V2)
- Using ILB
  - Internet-facing, multi-tier applications in which the back-end tiers are not Internet-facing but require load balancing for traffic from the Internet-facing tier.
  - Load balancing for line-of-business (LOB) applications hosted in Azure without requiring additional load balancer hardware or software.
- ILB Setup
  - PowerShell Only
    - Add-AzureInternalLoadBalancer
    - Add-AzureRMLoadBalancerFrontendIPConfig
    - Add-AzureRMLoadBalancerBackendAddressPoolConfig

ILB Scenario

- Intranet app running on Azure IaaS
- Cross-premises Azure virtual network
- Load balance not internet facing machines



Internet IP Addresses and Load Balancing

Public IP Addresses in Azure

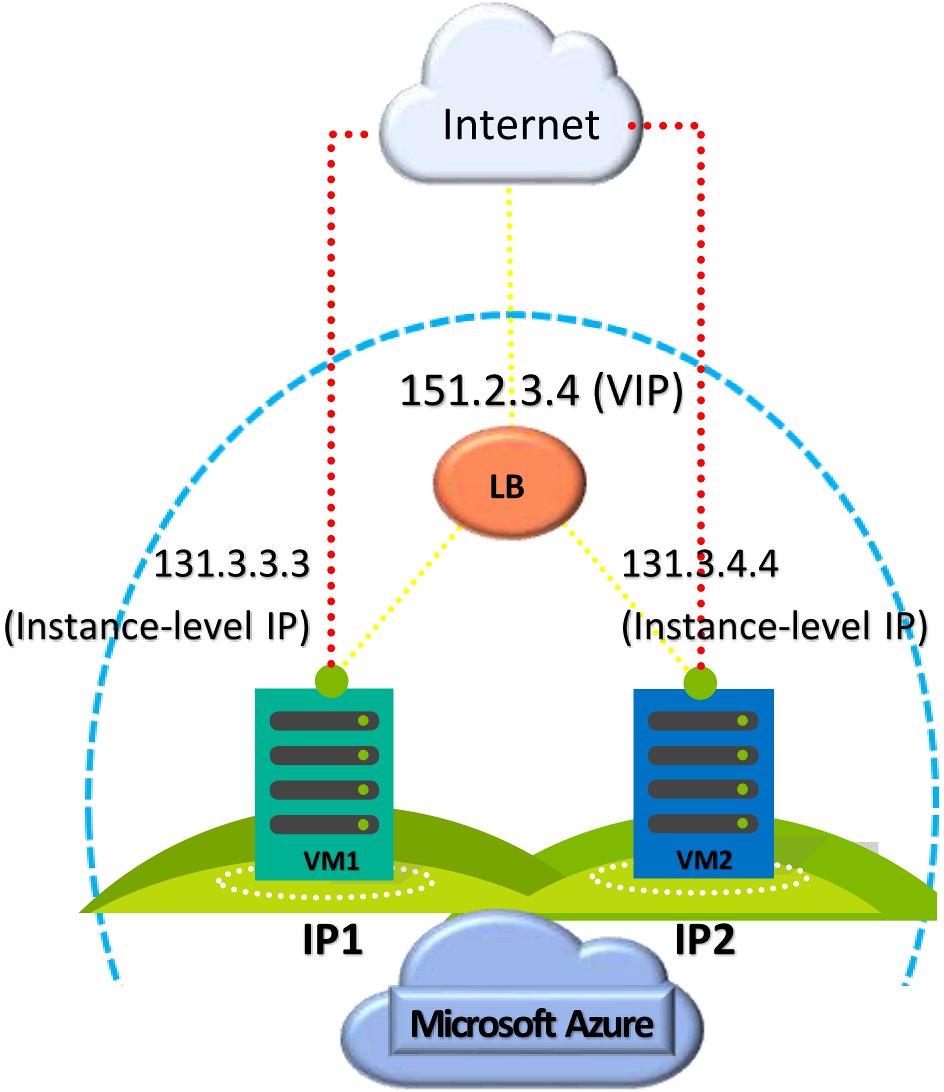
- Can be used for instance (VM) level access or load balancing

Instance-level IP (ILPIP)

- Internet IP assigned exclusively to single VM
  Entire port range accessible by default
- Primarily for targeting a specific VM

Load balanced IP (VIP)

- Internet IP load balanced among one or more VM instances
- Allows port redirection
- Primarily for load balanced, highly available, or auto-scale scenarios



Azure DNS Services

Azure DNS *Preview*

Host your DNS domains in Azure

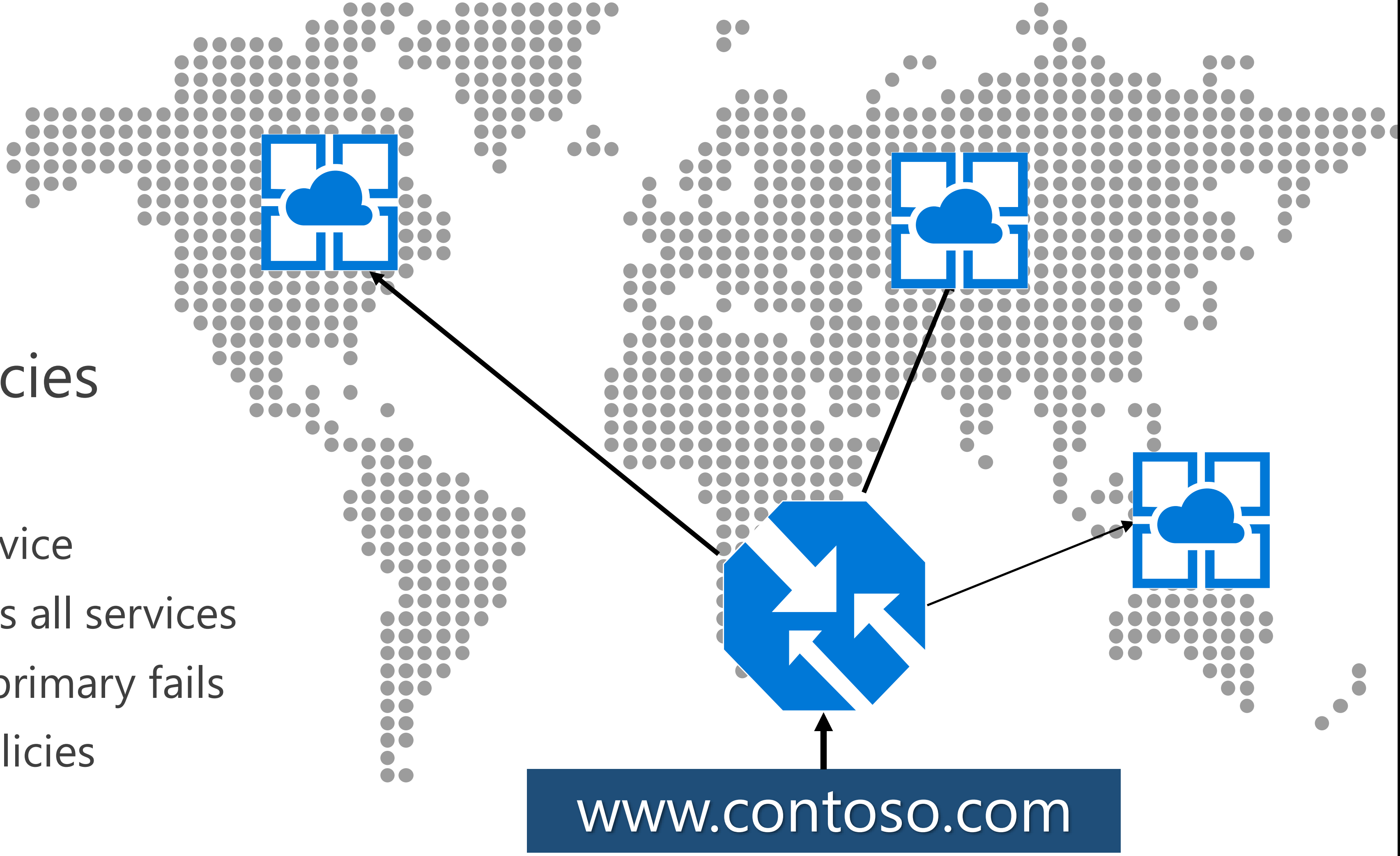
Integrate your Web and Domain hosting

Traffic Manager

Globally route user traffic with flexible policies

Enable best-of-class end to end user experience

Traffic Manager



Traffic Management Policies

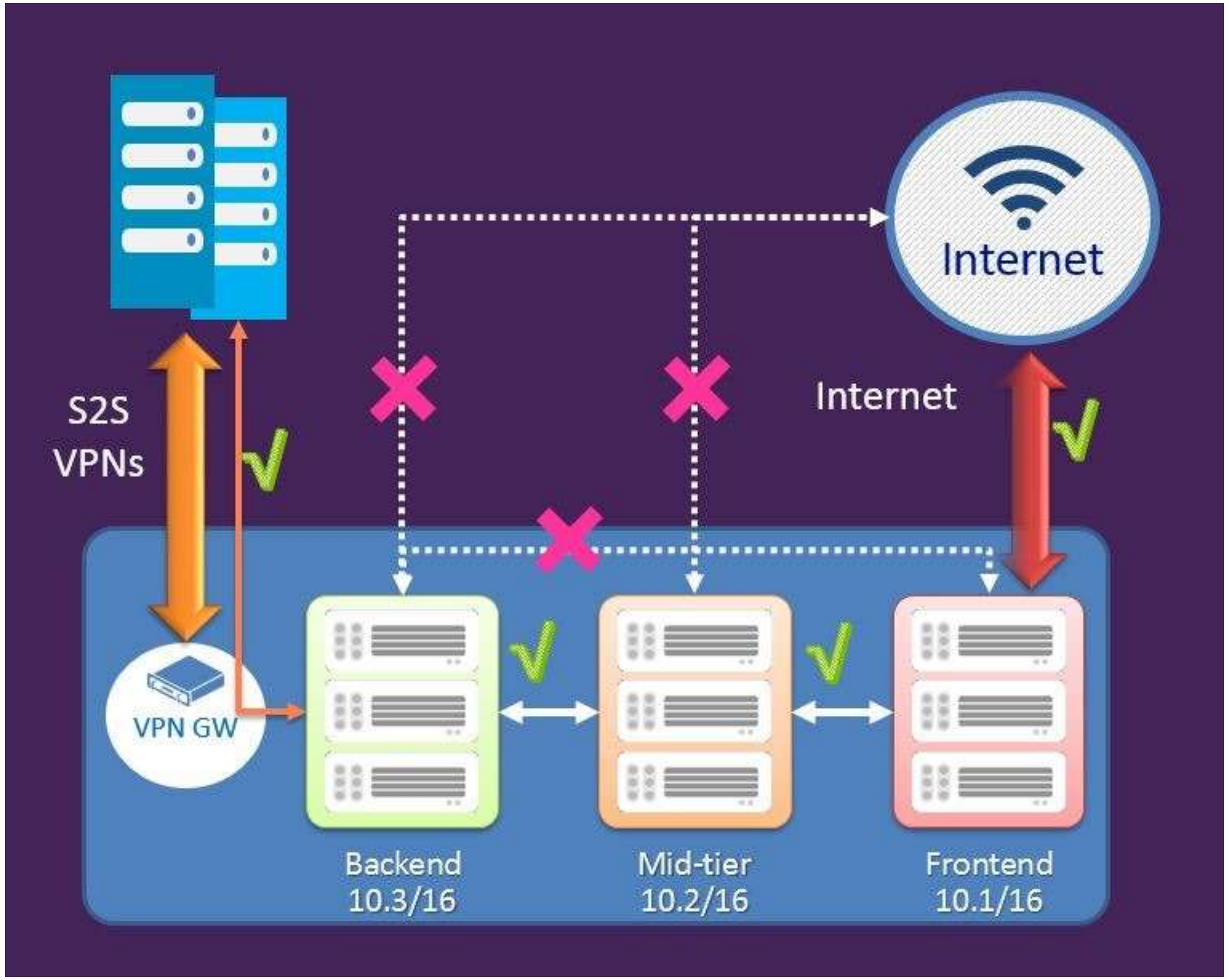
- **Latency** – Direct to "closest" service
- **Round Robin** – Distribute across all services
- **Failove**r – Direct to "backup" if primary fails
- **Nested** – Flexible multi-level policies

Module 03: IaaS Virtual Networking

Other Features

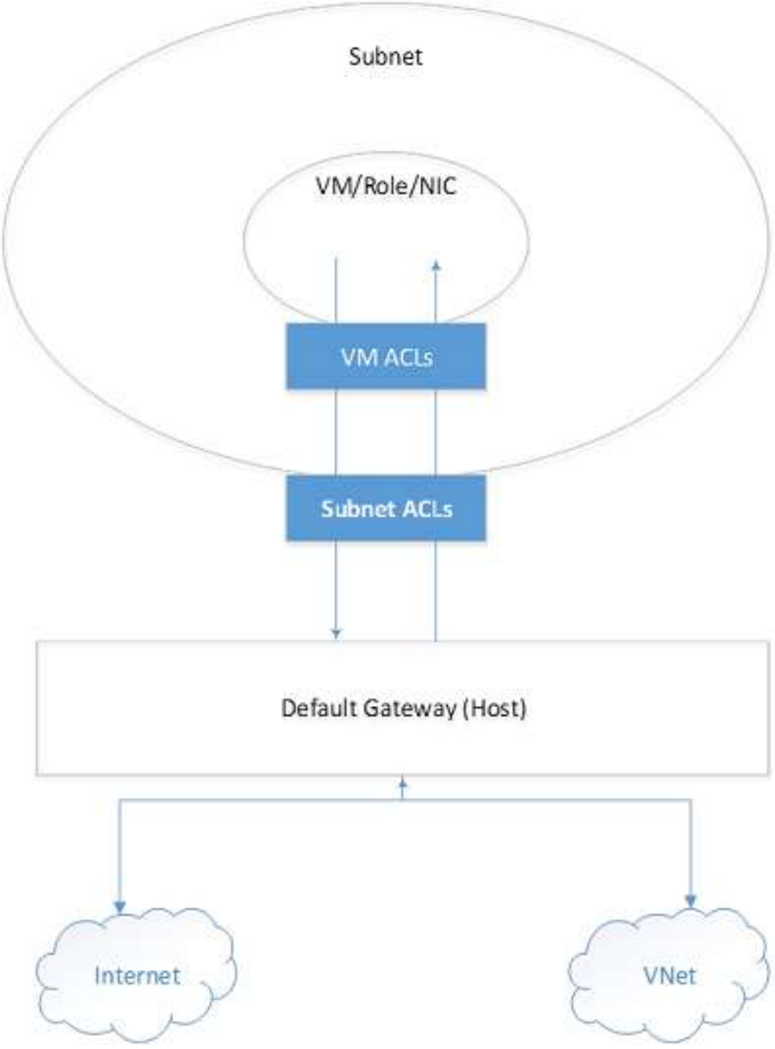
Network Security Groups (NSG)

- Define access control rules for inbound/outbound traffic to a VM or group of VMs in a subnet
- NSG rules can be changed at any time and apply to all instances
- NSG can be associated with:
  - A single VM in a VNet
  - A subnet in a VNet
  - A VM and a Subnet together for added security
- Rules are processed in order of priority
- Rules are based on 5-tuple (source/dest IP/port, protocol)



Network Security Groups (continued)

- Two different ACL groups, one for individual VM, one for Subnet
- Rules are applied to inbound traffic for subnet followed by rules for the VM
- Outbound rules are applied for VM first and then followed by subnet rules



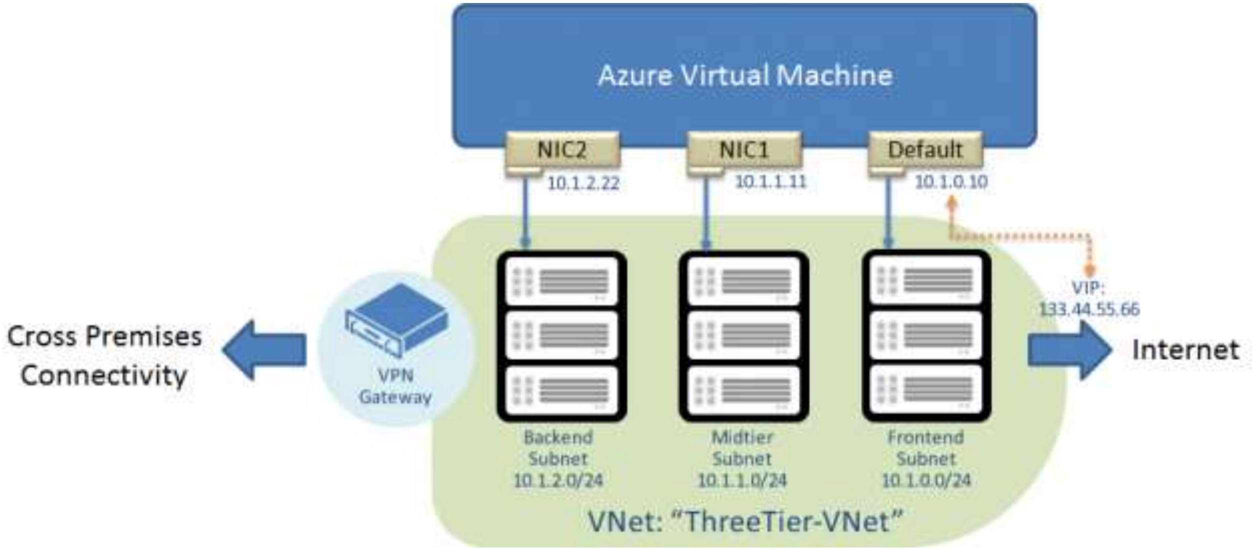
Example PowerShell:

```
New-AzureNetworkSecurityGroup -Name "MyVNetSG" -Location uswest
-Label "Security group for my Vnet in West US‟

Get-AzureNetworkSecurityGroup -Name "MyVNetSG" | Set-
AzureNetworkSecurityRule -Name WEB -Type Inbound -Priority 100
-Action Allow -SourceAddressPrefix 'INTERNET'  -SourcePortRange
'*' -DestinationAddressPrefix '*' -DestinationPortRange '*' -
Protocol TCP
```

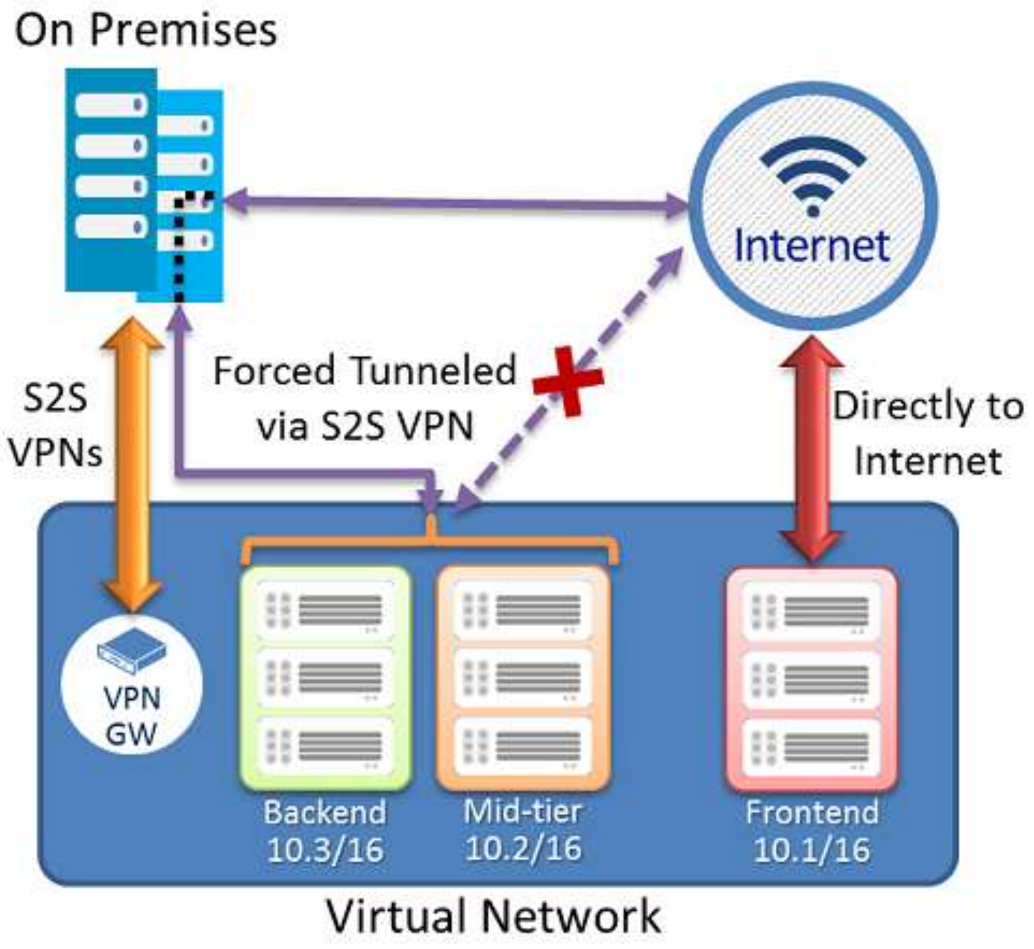
Multi-NIC Support

- Using multiple NICs on your VM allows you to manage network traffic better (16)
- Isolate traffic between front-end NICs and backend NICs
- Cannot add or remove NICs once VM is created
- Can have multiple NICs on any VM except for Basic SKU
- VMs must be in an Azure Virtual Network
- Additional NICs cannot be used in a load balanced set
- On-premise VM's with multiple NIC's migrated to Azure won't work – VM must be built in Azure



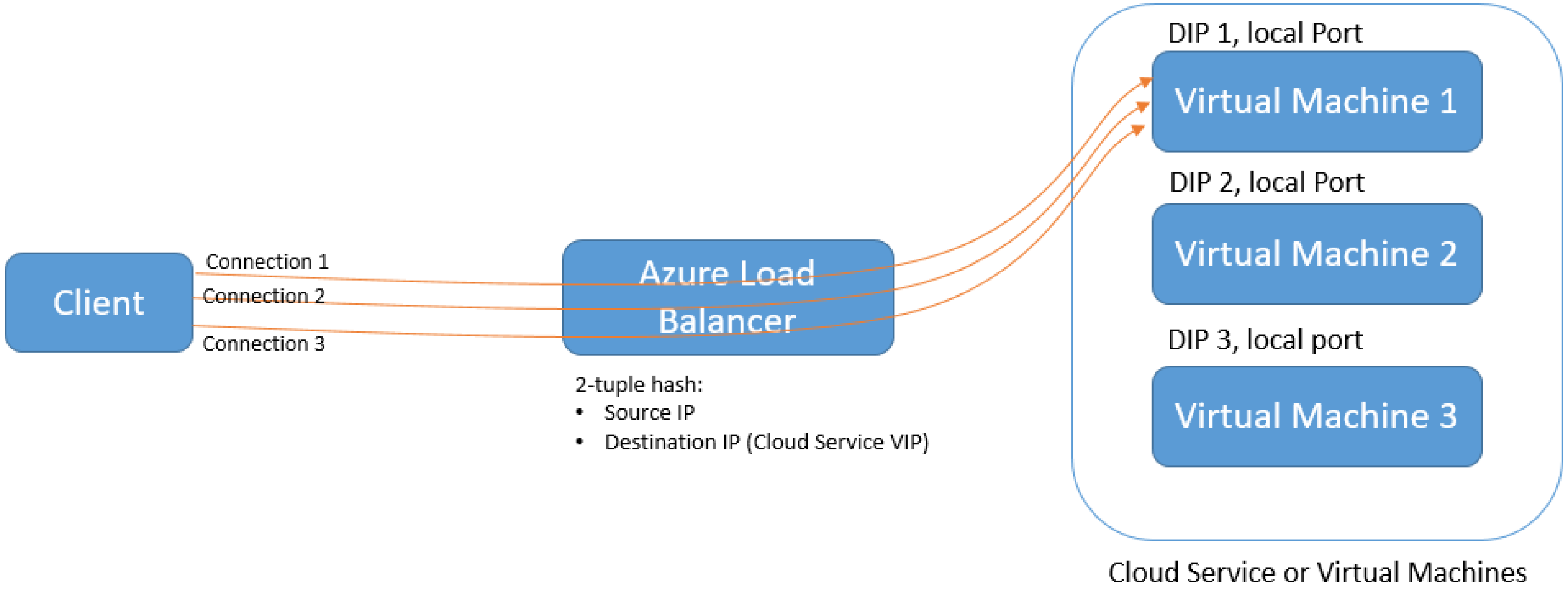
Forced Tunneling

- Force internet-bound traffic from a Cloud application back through on-premises network via Site-to-Site VPN/ExpressRoute
- Allows scenario for inspection and auditing of traffic
- Can create a routing table to create a default route, then associate routing table to VNet subnets



Source IP Affinity

- Azure Load Balancer – new distribution mode = Source IP Affinity
- Load balance traffic based on 2 or 3 tuple modes



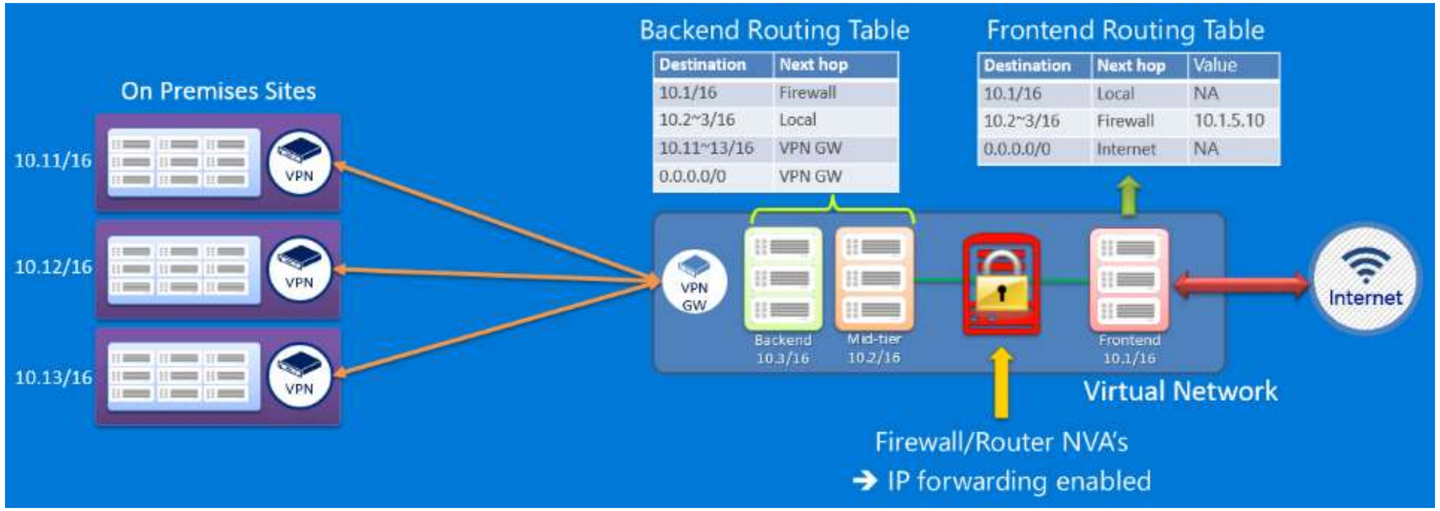
2-tuple hash:
- Source IP
- Destination IP (Cloud Service VIP)

Scenarios

- Configure load balancer distribution to an endpoint on a VM via PowerShell/Service Management API
- Configure load balancer distribution for your Load-Balanced Endpoint Sets via PowerShell/Service Management API.
- Configure load balancer distribution for your Web/Worker roles via the Service model (.csdef file)

User Defined Routing

- By default, Azure provides a route table based on your virtual network settings
- Need for custom routing may include
    - Use of a virtual appliance in your Azure environment, ex. Firewall
    - Implementing a virtual NAT appliance to control traffic between your Azure virtual network and the Internet
    - BGP Route – if you are using ExpressRoute, you can enable BGP to propagate routes from your on-premises network to Azure



Backend Routing Table

Destination	Next hop
10.1/16	Firewall
10.2~3/16	Local
10.11~13/16	VPN GW
0.0.0.0/0	VPN GW

Frontend Routing Table

Destination	Next hop	Value
10.1/16	Local	NA
10.2~3/16	Firewall	10.1.5.10
0.0.0.0/0	Internet	NA

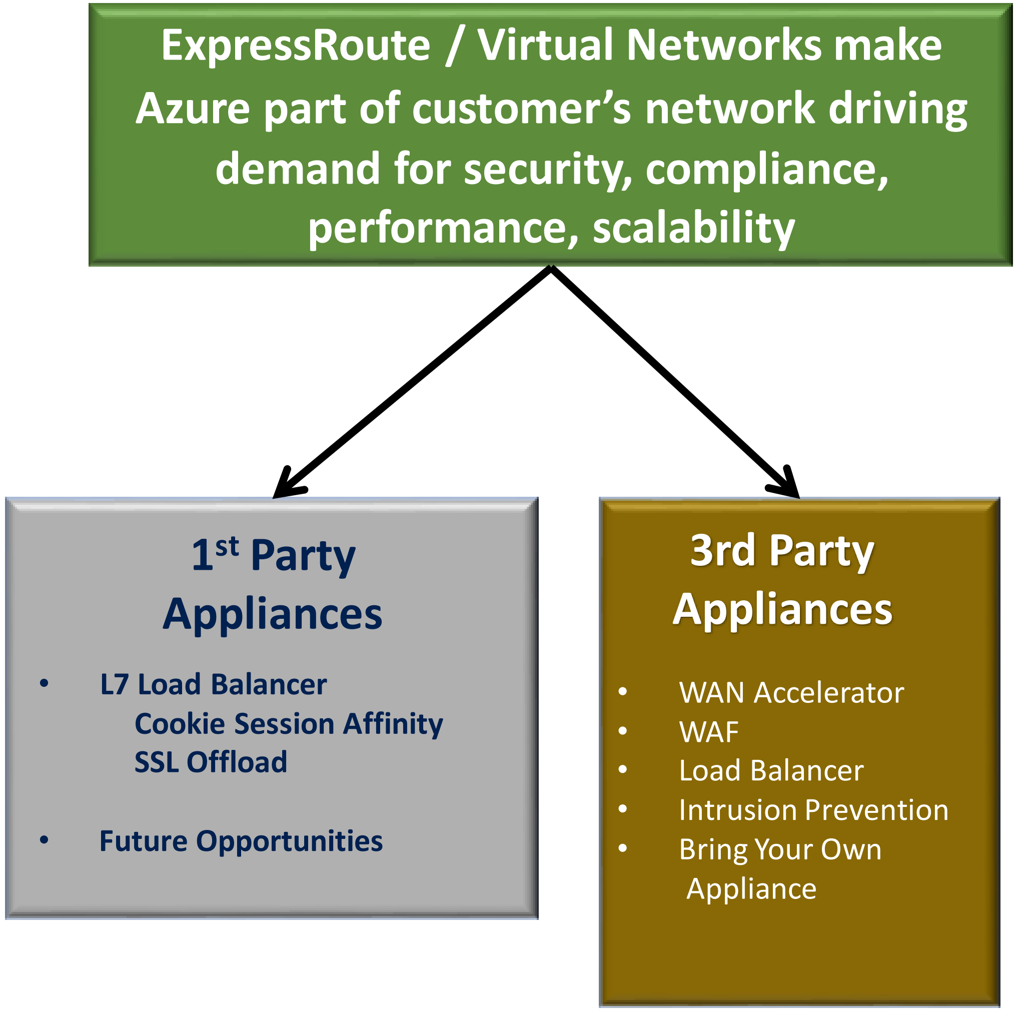
Ex. - All traffic directed to the mid-tier and backed subnets initiated from the front end subnet goes through a virtual firewall appliance

Module 4: IaaS Virtual Networking

Virtual Network Appliances

Virtual Network Appliances

- Overview
  - VMs that perform specific network functions
  - Focus: Security (Firewall, IDS , IPS), Router/VPN, ADC (Application Delivery Controller), WAN Optimization
  - Typically Linux or FreeBSD-based platforms
  - 1st and 3rd Party Appliances
- Scenarios
  - IT Policy & Compliance – Consistency between on premises & Azure
  - Supplement/complement Azure capabilities
- Azure Marketplace
  - Available through Azure Certified Program to ensure quality
    and simplify deployment
  - You can also bring your own appliance and license



ExpressRoute / Virtual Networks make Azure part of customer's network driving demand for security, compliance, performance, scalability

1st Party Appliances

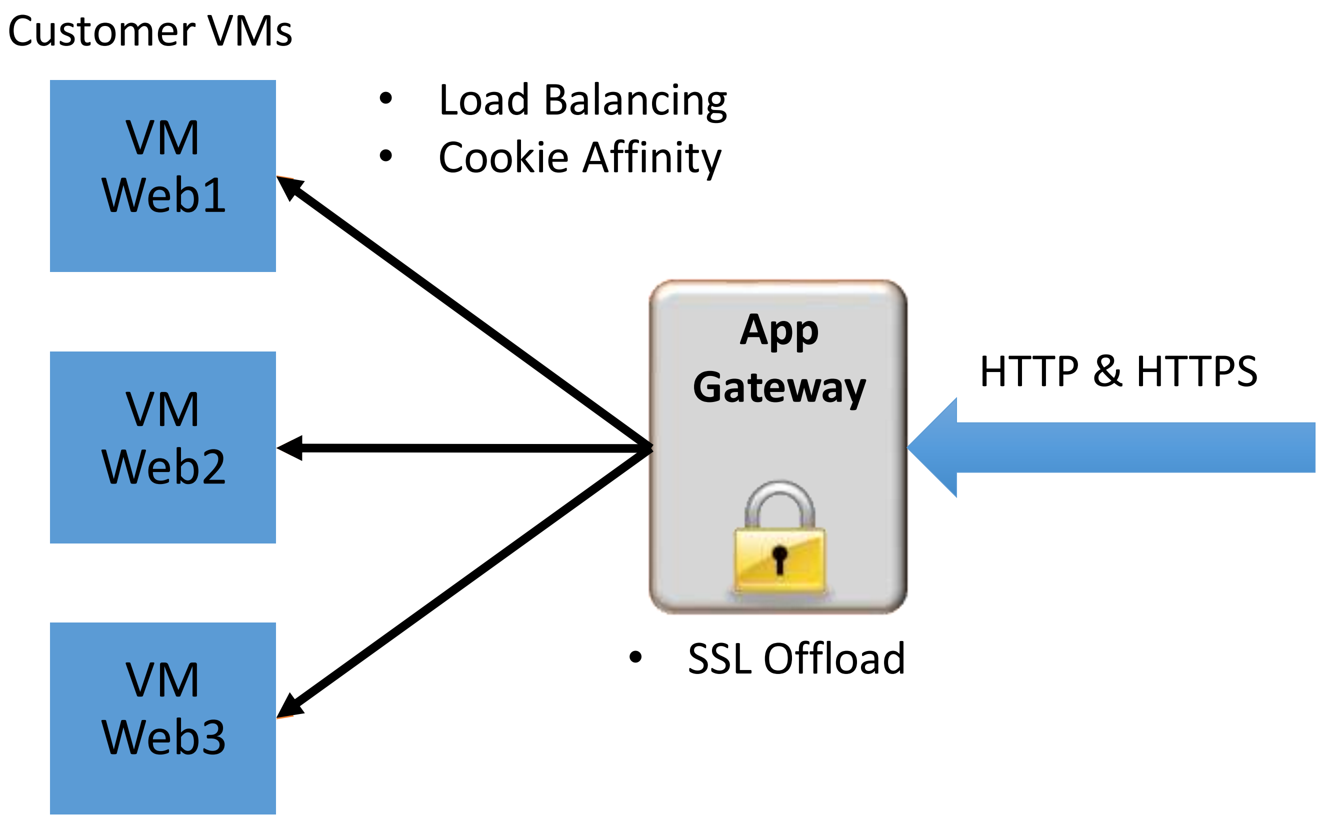
- **L7 Load Balancer**
  Cookie Session Affinity
  SSL Offload
- **Future Opportunities**

3rd Party Appliances

- WAN Accelerator
- WAF
- Load Balancer
- Intrusion Prevention
- Bring Your Own Appliance

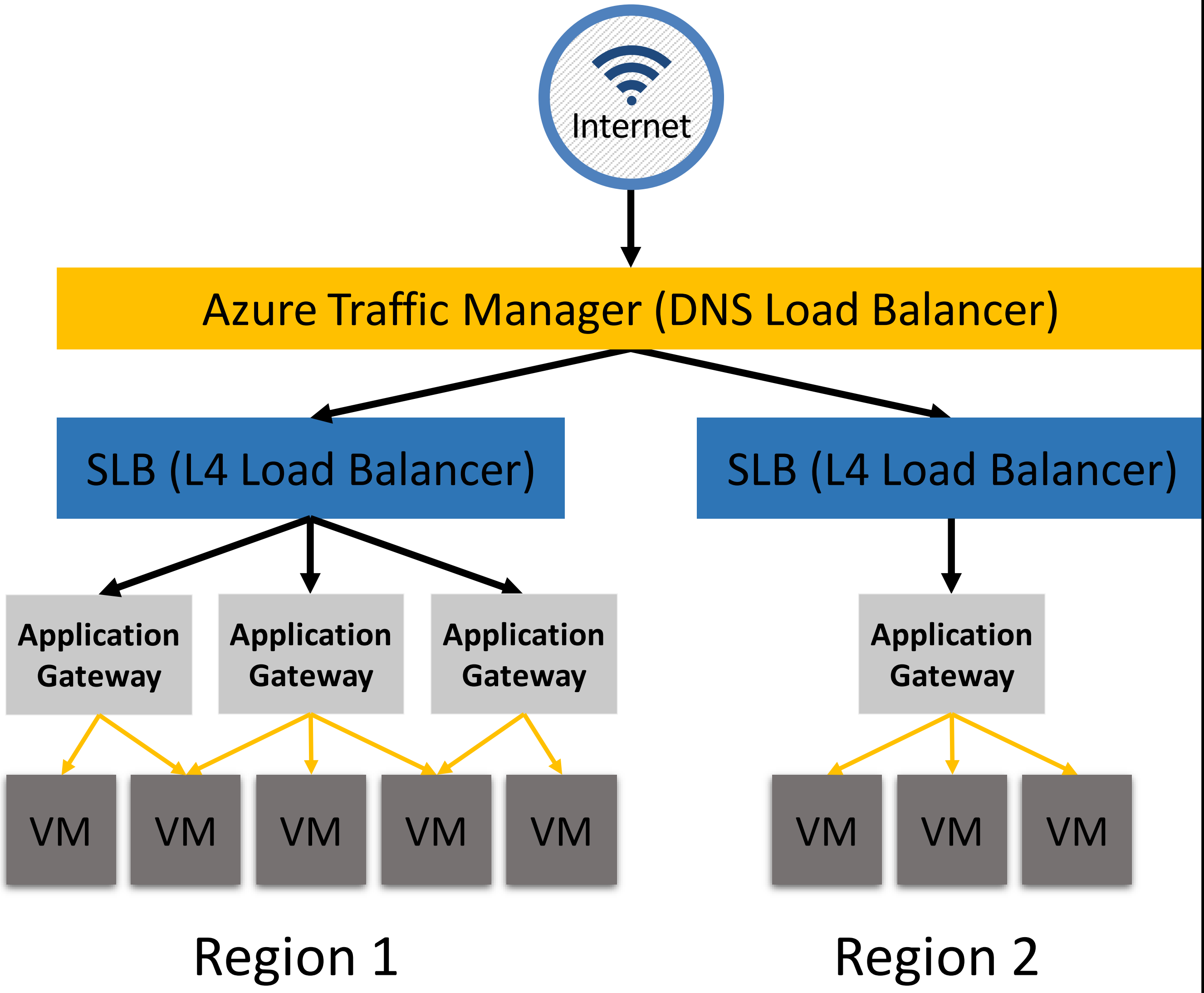
Azure Application Gateway

- Azure-managed, first-party virtual appliances
- HTTP routing based on app-level policies:
  - Cookie based session affinity
  - URL hash
  - Weight (load)
- SSL termination and caching
  - Centralize certificate management
  - Scalable backend provisioning



Application Gateway – LB Hierarchy

Azure Service	What	Example
Traffic Manager	Cross-region redirection & availability	http://news.com ➔ apac.news.com ➔ emea.news.com ➔ us.news.com
SLB	In-region scalability & availability	emea.news.com ➔ AppGw1 ➔ AppGw2 ➔ AppGw2
Application Gateway	URL/content-based routing & load balancing	news.com/topnews news.com/sports news.com/images
VMs	Web Servers	



Microsoft