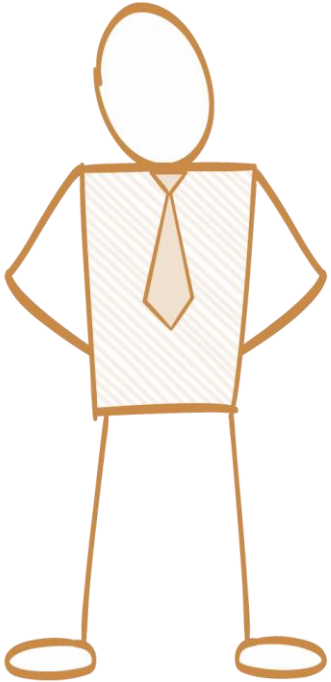
Architecting on AWS
Student Guide
Version 3.1

100-ARC-31-EN-SG



Module 4: Amazon VPC

Topics

- What is Amazon VPC?
- Core Components
- Key Features

Topics

- What is Amazon VPC?
- Core components
- Key Features

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VPC Introduction

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What is Amazon VPC?

Amazon Virtual Private Cloud (Amazon VPC) enables you to launch Amazon Web Services (AWS) resources into a **virtual network** that you've defined.

Divide your private IP address range into one or more public or private subnets

Specify your own private IP address range from any ranges you choose

Control inbound and outbound access to and from individual instances

Bridge your VPC and your onsite IT infrastructure with an encrypted VPN connection

Assign multiple IP address and attach multiple ENIs and EIPs to EC2 instances

Virtual Private Cloud (VPC)

Provision a **logically isolated section of the AWS Cloud** where you can launch AWS resources in a **virtual network** that you define

Topics

- What is Amazon VPC?
- Core components
- Key Features

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Core Components

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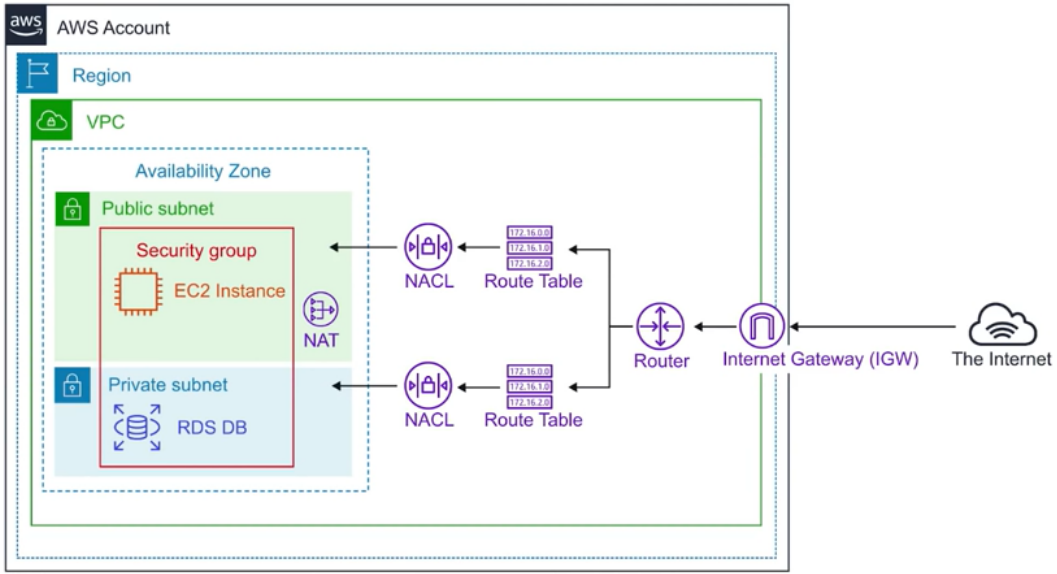
Introduction to VPC

Think of a AWS VPC as your own **personal data centre.**

Gives you complete control over your virtual networking environment



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Core Components

Combining these components and services is what makes up your VPC.

Internet Gateway (IGW)

Virtual Private Gateway (VPN Gateway)

Routing Tables

Network Access Control Lists (NACLs) - Stateless

Security Groups (SG) Stateful

Public Subnets

Private Subnets

Nat Gateway

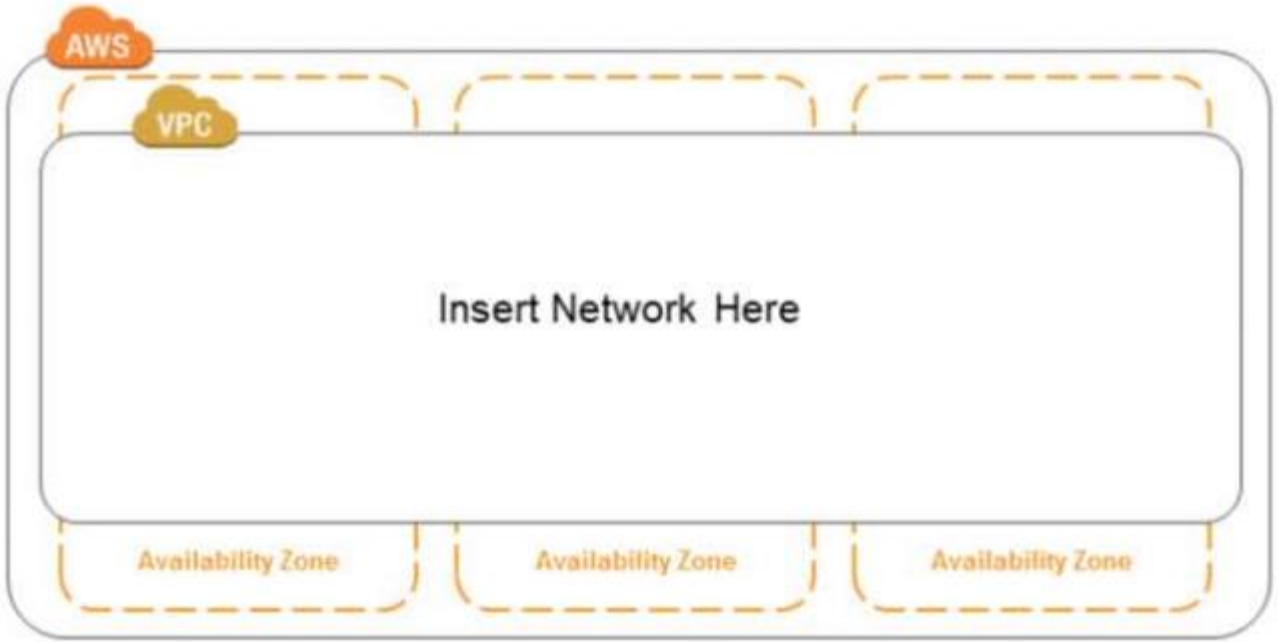
Customer Gateway

VPC Endpoints

VPC Peering

Core components

- Select an AWS region for your VPC

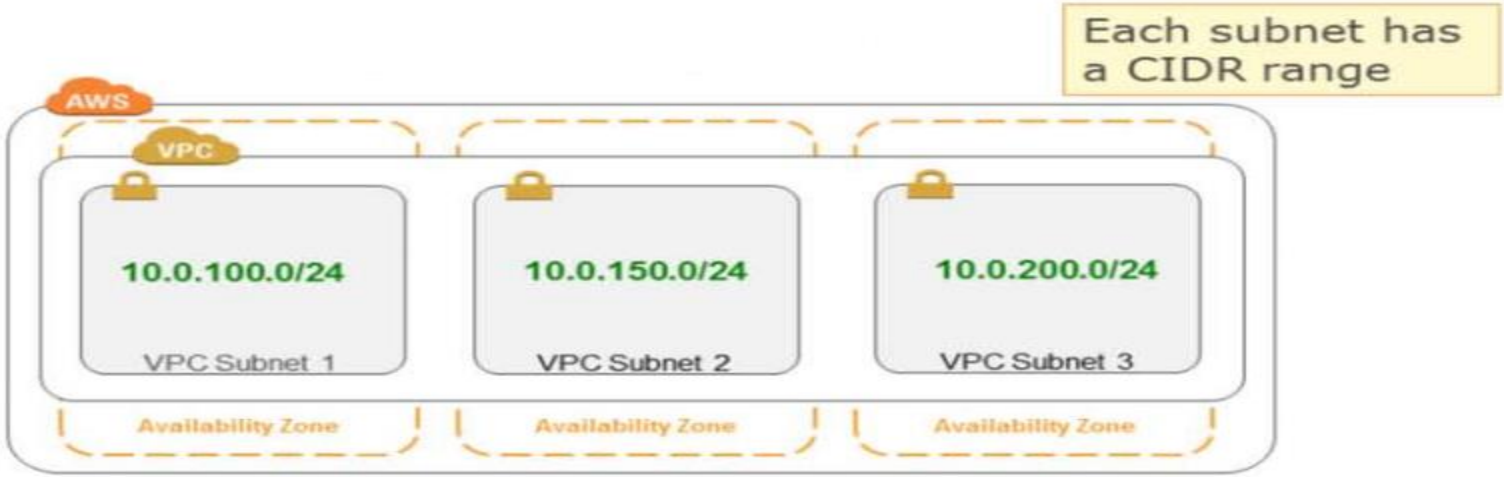


Core components

- Specify the size of our network with a CIDR block

Core components

- Create **subnets** inside the VPC
  - Subnets **do not** span Availability Zones



Core components

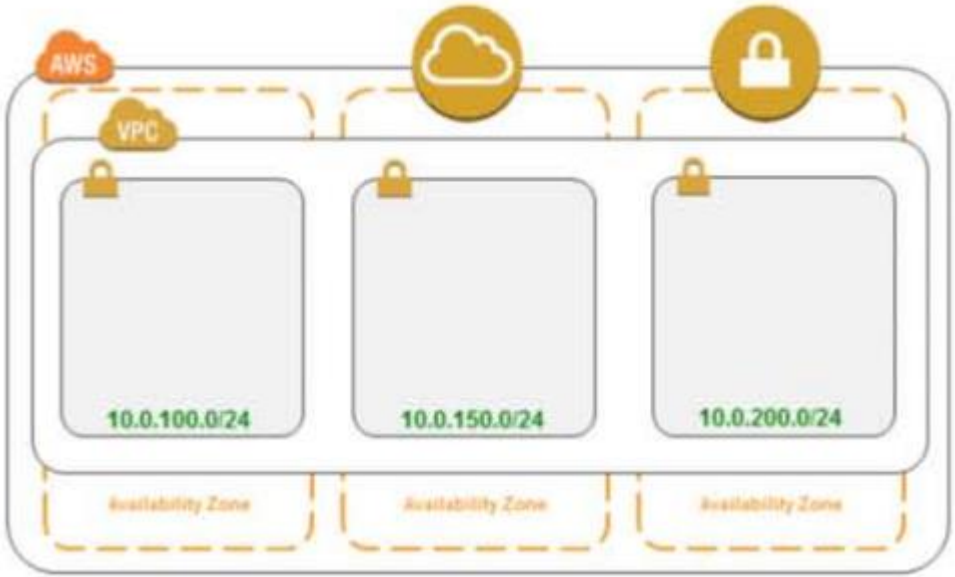
- Attach gateway devices to network

Core components

•VPN Gateway(VGW) allows subnet(s) to route to on-premises network over IPSEC VPN

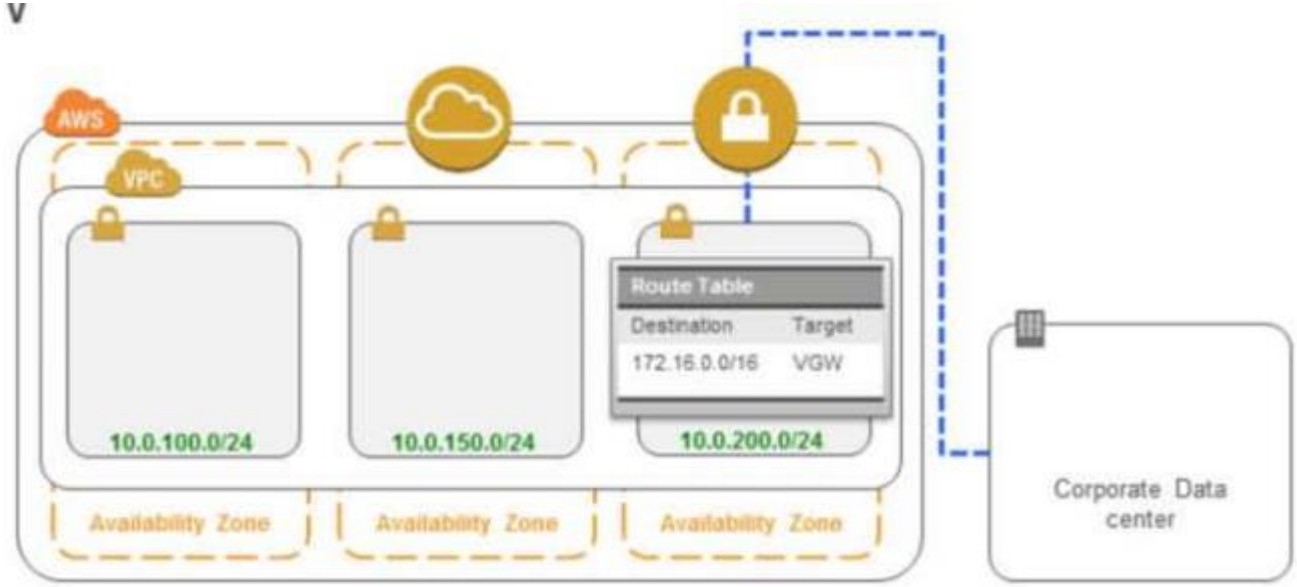
Core components

- Define custom routing rule(s) for each subnet



Core components

•Private subnet with IPSEC VPN to corporate datacenter via VGW



Core components

•Public subnet with inbound/outbound Internet connectivity via IGW

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Topics

- What is Amazon VPC?
- Core components
- Key Features

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Key Features

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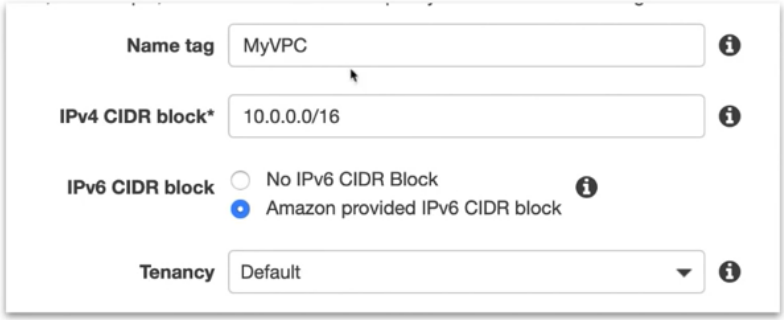
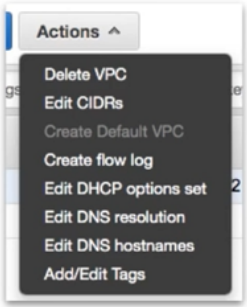
Key Features

- VPCs are **Region Specific** they do not span regions
- You can create upto **5 VPC** per region.
- Every region comes with a default VPC
- You can have **200 subnets** per VPC
- You can use **IPv4 Cidr Block** and in addition to a **IPv6 Cidr Blocks** (the address of the VPC)
- **Cost nothing:** VPC's, Route Tables, Nacls, Internet Gateways, Security Groups and Subnets, VPC Peering
- **Some things cost money:** eg. NAT Gateway, VPC Endpoints, VPN Gateway, Customer Gateway
- **DNS hostnames** (should your instance have domain name addresses)



IPv6 Cidr Block 2600:1f16:9e0:8d00::/56



Disabled by default, turn on **hostnames**

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Default VPC

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Default VPC

AWS has a default VPC in every region so you can **immediately** deploy instances.

- Create a VPC with a size /16 IPv4 CIDR block (172.31.0.0/16).
- Create a size /20 **default subnet in each Availability Zone**.
- Create an **Internet Gateway** and connect it to your default VPC.
- Create a **default security group** and associate it with your default VPC.
- Create a **default network access control list (NACL)** and associate it with your default VPC.
- Associate the **default DHCP** options set for your AWS account with your default VPC.
- *When you create a VPC, it automatically has a main route table

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Default Everywhere IP

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0.0.0.0/0

0.0.0.0/0 is also know as **default**

It represents **all possible IP addresses**

When we specify **0.0.0.0/0** in our route table for IGW we are allow internet access
When we specific **0.0.0.0/0** in our security groups inbound rules we are allowing all traffic from the internet access our public resources

When you see **0.0.0.0/0**, just *think* of giving access from anywhere or the internet.

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VPC Peering

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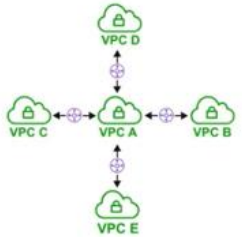
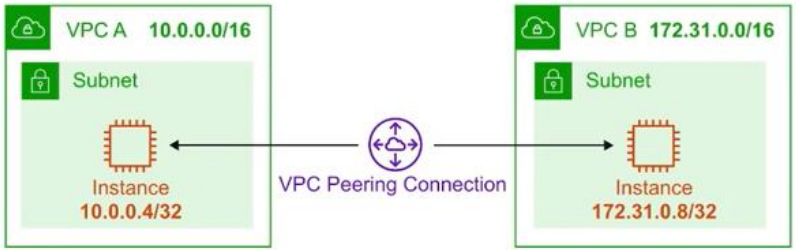
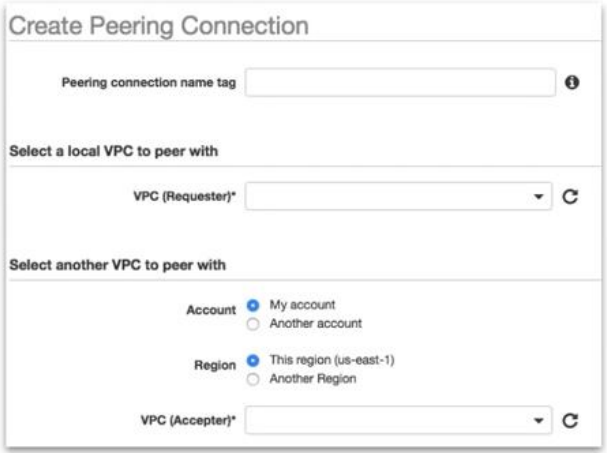
VPC Peering

VPC Peering allows you to connect one VPC with another over a **direct network route** using **private IP addresses.**

- Instances on peered VPCs **behave** just like they are on the **same network**
- Connect VPCs across **same** or **different AWS accounts** and **regions**
- Peering uses a **Star Configuration: 1 Central VPC - 4 other VPCs**
- **No Transitive Peering** (peering must take place directly between VPCs)
  - Needs a one to one connect to immediate VPC
- **No Overlapping CIDR Blocks**







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172.16.0.0
172.16.1.0
172.16.2.0

Route Tables

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Route Tables

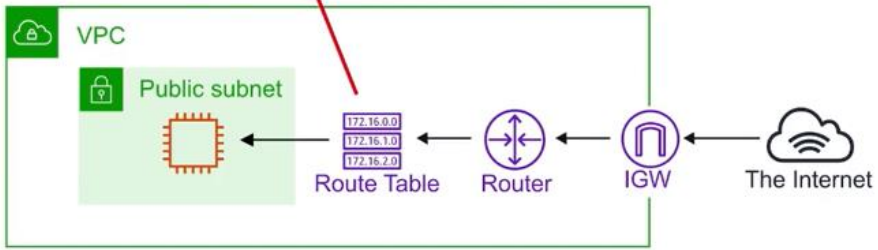
Route tables are used to determine where **network traffic is directed**

Each **subnet** in your VPC **must be associated** with a route table

Each record is called a “route”

A subnet can only be associated **with one route table at a time**, but you can associate multiple subnets with the same route table.

Destination	Target	Status	Propagated
10.0.0.0/16	local	active	No
0.0.0.0/0	igw-19e3a2e134fe086e2	active	No



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Internet Gateway

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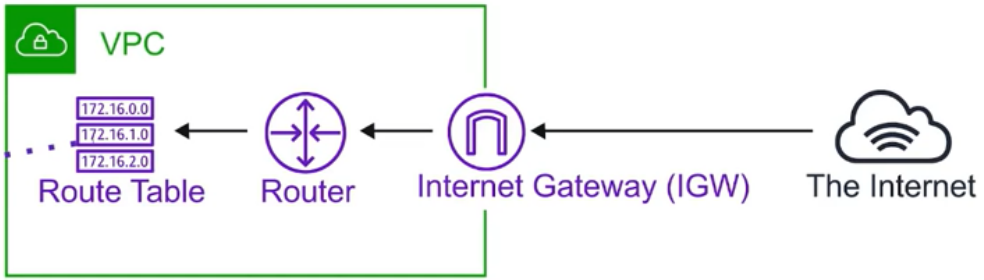
Internet Gateway (IGW)

The Internet Gateway allows **your VPC access to the internet**.

IGW does ✌️ two things:

1. provide a target in your VPC route tables for internet-routable traffic
2. perform network address translation (NAT) for instances that have been assigned **public IPv4 addresses**.

Destination	Target
10.0.0.0/16	local
0.0.0.0/0	**igw-id**



To route out to the internet you need to add in your route tables you need to add a route
To the internet gateway and set the Destination to be **0.0.0.0/0**

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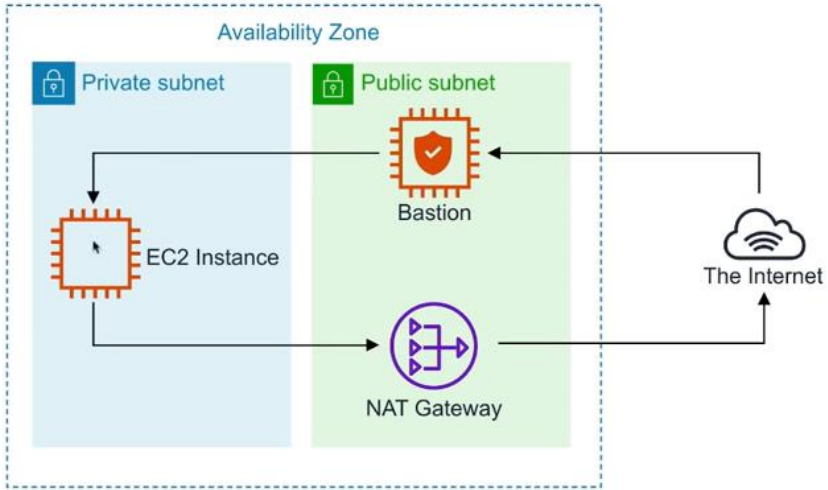
Bastion / Jumpbox

Bastions are EC2 instances which are security harden. They are designed to help you gain access to your EC2 Instances via SSH or RCP That are in a **private subnet**.

They are also known as Jump boxes because you are jumping from one box to access another.

NAT Gateways/Instances are only intended for EC2 instances to gain outbound access to the internet for things such as security updates. NATs cannot/should not be used as Bastions



System Manager's **Sessions Manager** replaces the need for Bastions

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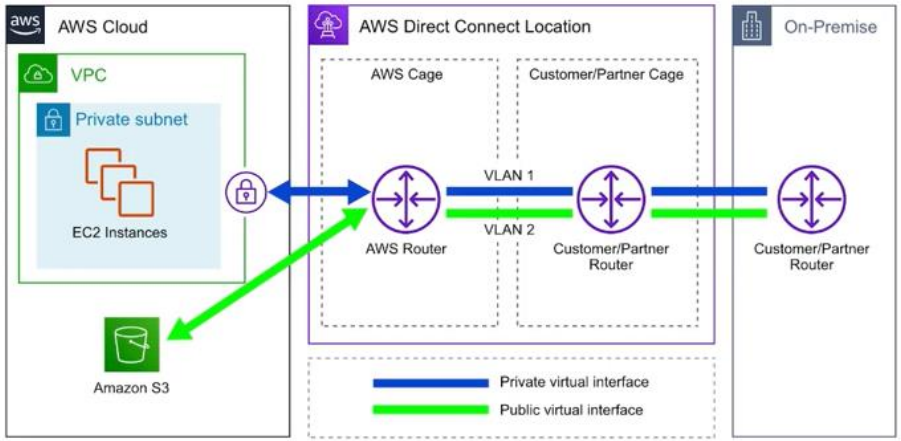
Direct Connect

Direct Connect

AWS Direct Connect is the AWS solution for establishing
dedicated network connections from on-premises locations to AWS.

Very fast network Lower Bandwidth **50M-500M** or Higher Bandwidth **1GB** or **10GB**



- Helps **reduce network costs** and **increase bandwidth throughput**. (great for high traffic networks)
- Provides a **more consistent network experience** than a typical internet-based connection. (reliable and secure)

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VPC Endpoints Introduction

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VPC Endpoints

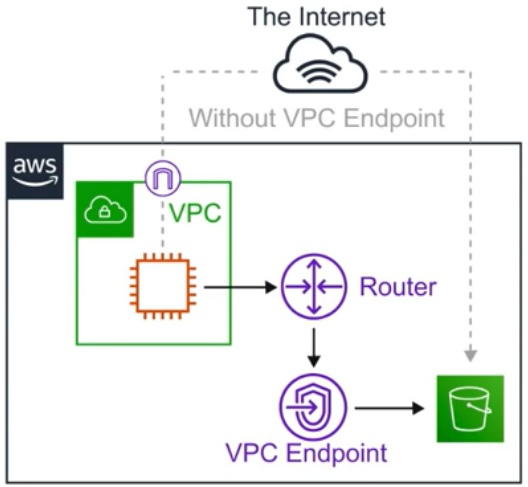
Think of a secret tunnel where you don't have to leave the AWS network

VPC Endpoints allow you to **privately connect your VPC to other AWS services**, and VPC endpoint services.

There are ✌️ **2 Types** of VPC Endpoints

1. Interface Endpoints
2. Gateway Endpoints

- **Eliminates** the need for an **Internet Gateway**, **NAT device**, **VPN connection**, or **AWS Direct Connect** connections.
- **Instances** in the VPC **do not require a public IP address** to communicate with service resources.
- **Traffic** between your VPC and other services **does not leave the AWS network**.
- **Horizontally scaled**, **redundant**, and **highly available** VPC component.
- Allows secure communication between instances and services - **without adding availability risks or bandwidth constraints** on your traffic.



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Interface Endpoints

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Interface Endpoints

Interface Endpoints are **Elastic Network Interfaces (ENI)** with a **private IP address**.
They serve as an entry point for traffic going to a supported service.

Interface Endpoints are powered by **AWS PrivateLink**

Access services hosted on AWS easily and securely by keeping your network traffic within the AWS network

Pricing per VPC endpoint per AZ ($/hour)	**0.01**	~$7.5 / mo
Pricing per GB data processed ($)	**0.01**	

Interface Endpoints support the following AWS Services...

- API Gateway
- CloudFormation
- CloudWatch
- Kinesis
- SageMaker
- Codebuild
- AWS Config
- EC2 API
- ELB API
- AWS KMS
- Secrets Manager
- Security Token Service
- Service Catalog
- SNS
- SQS
- Systems Manager
- Marketplace Partner Services
- Endpoint Services in other AWS accounts

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Gateway Endpoints

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VPC Gateway Endpoints

VPC Gateway Endpoints are **Free!**

A **Gateway Endpoint** is a gateway that is a target **for a specific route** in your **route table**, used for traffic destined for a supported AWS service.

To create a Gateway Endpoint, you must specify the VPC in which you want to create the endpoint, and the service to which you want to establish the connection.

AWS Gateway Endpoint currently only supports 2 services...

- Amazon S3
- DynamoDB

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VPC Endpoints Cheat Sheet

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VPC Endpoint *CheatSheet*

- VPC Endpoints help keep traffic between AWS services **within the AWS Network**
- There are two kinds of VPC Endpoints. Interface Endpoints and Gateway Endpoints
- Interface Endpoints **cost money**, Gateway Endpoints **are free**
- Interface Endpoints uses an Elastic Network Interface (ENI) with Private IP (powered by AWS PrivateLink)
- Gateway Endpoints is a target for a specific route in your route table
- Interface Endpoints support many AWS services
- Gateway Endpoint only support DynamoDB and S3

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VPC Flow Logs Introduction

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VPC Flow Logs

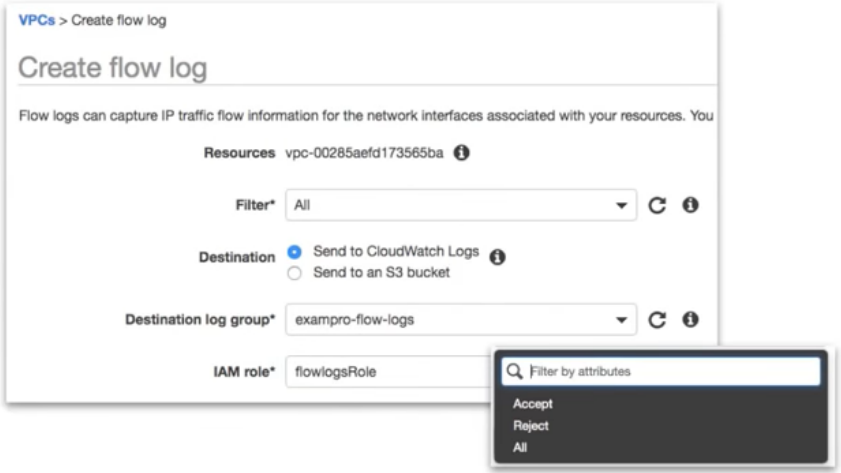
VPC Flow Logs allow you to capture **IP traffic information** in-and-out of Network Interfaces within your VPC.

Flow Logs can be created for.

1. **VPC**
2. **Subnets**
3. **Network Interface**

Flow Logs

Look for this tab



All log data is **stored** using Amazon **CloudWatch Logs**.

After a Flow Log is created it can be viewed in detail within CloudWatch Logs

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VPC Flow Logs Log Breakdown

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VPC Flow Logs

```
<version> <account-id> <interface-id> <srcaddr> <dstaddr> <srcport> <dstport> <protocol> <packets> <bytes> <start>
<end> <action> <log-status>
```

```
2 123456789010 eni-abc123de 172.31.16.139 172.31.16.21 20641 22 6 20 4249 1418530010 1418530070 ACCEPT OK
```

version The VPC Flow Logs version.
account-id The AWS account ID for the flow log.
interface-id The ID of the network interface for which the traffic is recorded.
srcaddr The source **IPv4 or IPv6 address**. The IPv4 address of the network interface is always its private IPv4 address.
dstaddr The destination **IPv4 or IPv6 address**. The IPv4 address of the network interface is always its private IPv4 address.
srcport The source port of the traffic.
dstport The destination port of the traffic.
protocol The IANA protocol number of the traffic. For more information, see Assigned Internet Protocol Numbers.
packets The number of packets transferred during the capture window.
bytes The number of bytes transferred during the capture window.
start The time, in Unix seconds, of the start of the capture window.
end The time, in Unix seconds, of the end of the capture window.
action The action associated with the traffic:
- ACCEPT: The recorded traffic was permitted by the security groups or network ACLs.
- REJECT: The recorded traffic was not permitted by the security groups or network ACLs.

log-status The logging status of the flow log:
- OK: Data is logging normally to the chosen destinations.
- NODATA: There was no network traffic to or from the network interface during the capture window.
- SKIPDATA: Some flow log records were skipped during the capture window. This may be because of an internal capacity constraint, or an internal error.

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VPC Flow Logs Cheat Sheet

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VPC Flow Logs *CheatSheet*

- **VPC Flow Logs** monitor the in-and-out traffic of your Network Interfaces within your VPC
- You can turn on Flow Logs at the VPC, Subnet or Network Interface level
- VPC Flow Logs **cannot be tagged** like other AWS resources
- You **cannot change the configuration** of a flow log **after it's created**.
- You **cannot enable** flow logs for VPCs which are peered with your VPC **unless it is in the same account**
- VPC Flow Logs can be delivered to an **S3** or **CloudWatch Logs**
- VPC Flow Logs contains the source and destination **IP addresses** (not hostnames)
- Some instance traffic is **not monitored:**
    - Instance traffic generated by contacting the AWS DNS servers
    - Windows license activation traffic from instances
    - Traffic to and from the instance metadata address (169.254.169.254)
    - DHCP Traffic
    - Any traffic to the reserved IP address of the default VPC router

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Network Access Control List Introduction

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Network Access Control List (NACLs)

An (optional) layer of security that acts
As a **firewall** for controlling traffic **in and out of subnet(s)**

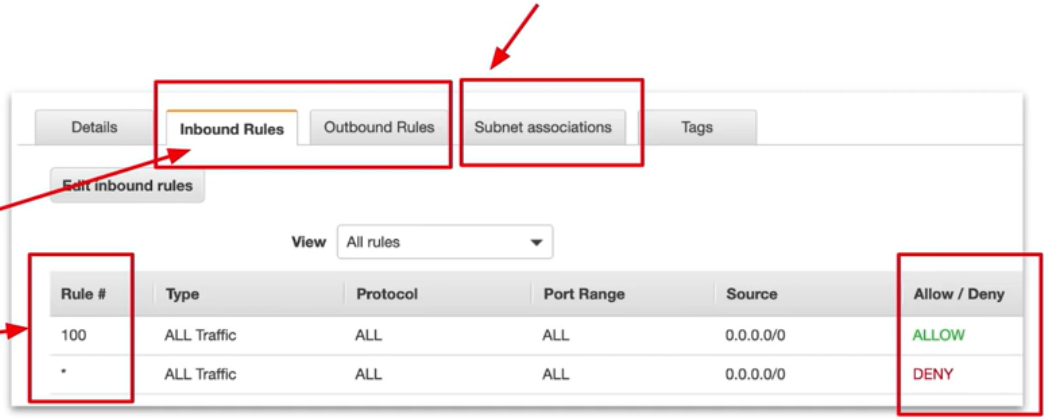
NACLs – Introduction

NACLs acts as a **virtual firewall** at the subnet level

VPCs automatically get a default NACL

Subnets are associated with NACLs. Subnets can only belong to a single NACL.

Each NACL contains a set of rules that can **allow** or **deny** traffic **into (inbound) and out of (outbound) subnets**



Rule # determines the **order of evaluation**. From lowest to highest. The highest rule # can be 32766 and its recommended to work in 10 or 100 increments.

You can allow or deny traffic. You **could block a single IP address** (You can't do this with Security Groups)

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NACL Use Case

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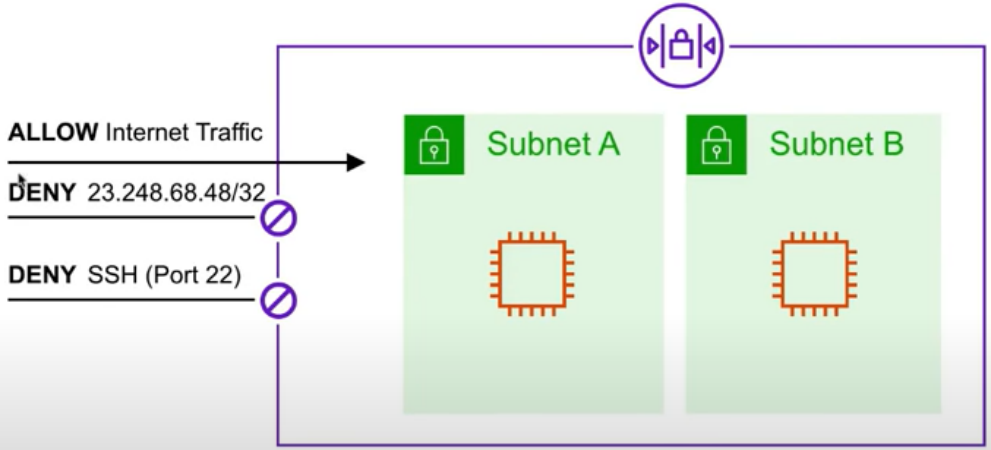
NACLs – Use Case

We determine there is a malicious actor at a specific IP address is trying to access our instances so we block their IP

We never need to SSH into instances so we add a DENY for these subnets. This is just an additional measure in case our Security Groups SSH port was left open.



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NACL Cheat Sheet

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NACLs *CheatSheet*

- Network Access Control List is commonly known as NACL
- VPCs are automatically given a default NACL which allows **all** outbound and inbound traffic.
- Each subnet within a VPC must be associated with a NACL
- Subnets can only be associated with 1 NACL at a time. Associating a subnet with a new NACL will remove the previous association.
- If a NACL is not explicitly associated with a subnet, the subnet will automatically be associated with the default NACL.
- NACL has inbound and outbound rules (just like Security Groups).
- Rule can either **allow** or **deny** traffic. (unlike Security Groups which can only allow)
- NACLs are STATELESS (any allowed inbound traffic is also allowed outbound)
- When you create a NACLs it will deny all traffic by default
- NACLs contain a numbered list of rules that gets evaluated in order from lowest to highest.
- If you needed to block a single IP address you could via NACLs (Security Groups cannot deny)

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SG

Security Groups Introduction

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sg-exampro

Security Groups

A virtual firewall that controls the traffic to and from EC2 Instances

Security Groups – Introduction

Security Groups acts as a **virtual firewall** at the instance level

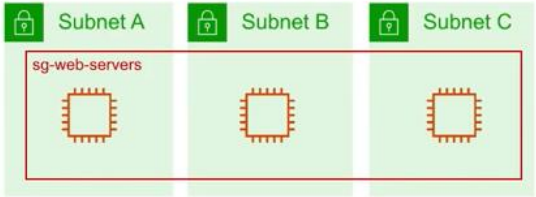
Security Groups are associated with EC2 instances

provide security at the **protocol** and **port** access level.

Each Security Group contains a set of rules that filter traffic coming **into (inbound) and out of (outbound)** EC2 instances.

There are no 'Deny' rules. **All traffic is blocked by default** unless a rule specifically allows it.

Multiple Instances across multiple subnets can belong to a **Security Group.**



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SG

Security Groups Use Cases

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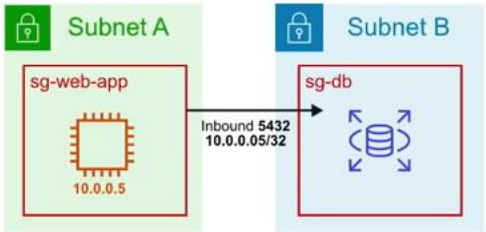
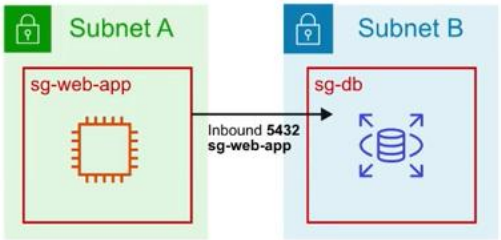
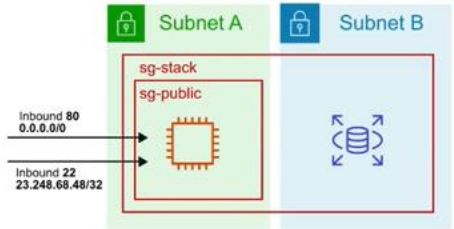
Security Groups – Use Case



You can specify the source to be an IP range or
A specific ip (/32 is a specific IP Address)



You can specify the source to be another security group



An instance can **belong to multiple Security Groups**, and rules are **permissive** (instead of restrictive). Meaning if you have one security group which has no Allow and you add an allow to another than it will Allow.

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Security Groups Limits

Security Groups – Limits

You can have **upto 10,000 Security Groups in a Region** (default is 2,500)

You can have **60 inbound rules** and **60 outbound rules** per security group

16 Security Groups per Elastic Network Interface (ENI) (default is 5)

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Security Groups Cheat Sheet

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Security Groups *CheatSheet*

- Security Groups acts as a firewall at the instance level
- Unless allowed specifically, all **inbound traffic** is **blocked by default**.
- All **Outbound traffic** from the instance is **allowed by default.**
- You can specific for the source to be either an IP range, single Ip Address or another security group
- Security Groups are **STATEFUL** (if traffic is allowed inbound it is also allowed outbound)
- Any changes to a Security Group take effect immediately.
- EC2 Instances can belong to multiple security groups
- Security groups can contain multiple EC2 Instances.
- You **cannot block specific IP addresses** with Security Groups, for this you would need a Network Access Control List (NACL)
- You can have upto 10,000 Security Groups per Region (default 2,5000)
- You can have 60 inbound and 60 outbound rules pre Security Group
- You can have 16 Security Groups associated to an ENI (default is 5)

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Network Address Translation Introduction

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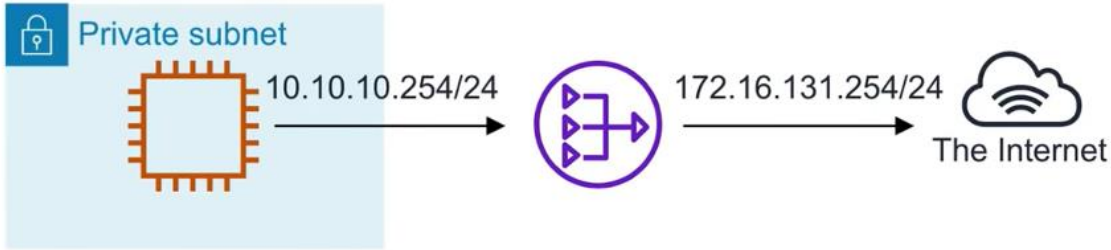
Network Address Translation (NAT)

Network Address Translation (NAT) is the
method of **re-mapping** one IP address space into another.



If you have a private network and you need to help gain outbound access to the internet you would need to use a NAT gateway to remap the Private IPs

If you have two networks which have conflicting network addresses you can use a NAT to make the addresses more agreeable

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NAT Instances VS NAT Gateways

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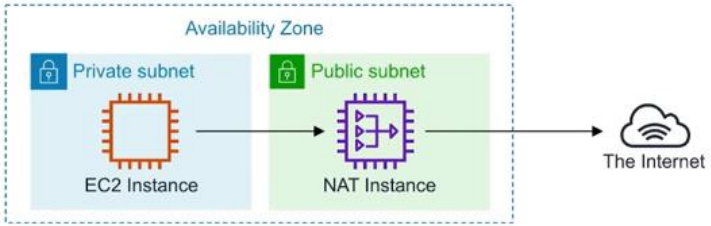
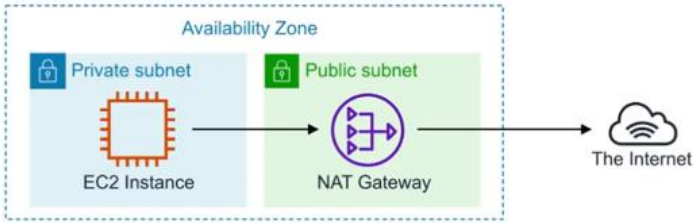
NAT Instances vs NAT Gateways

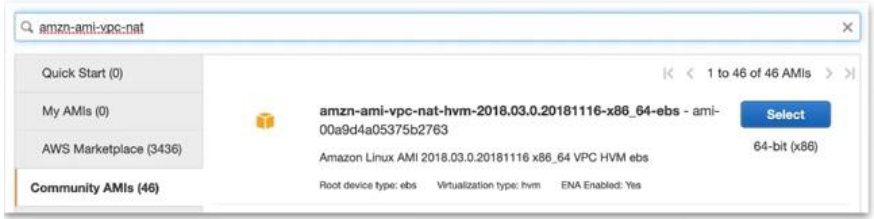
NATs have to run within a **Public Subnet**

NAT Instances (legacy) are individual EC2 instances. Community AMIs exist to launch NAT Instances.



NAT Gateways is a managed service which launches redundant instances within the selected AZ.





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NAT Cheat Sheet

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NAT Instance and NAT Gateway *CheatSheet*

- When creating a NAT instance you **must disable source and destination checks** on the instance
- NAT instances **must exist in a public subnet**
- You must have a **route out** of the private subnet to the NAT instance
- The size of a NAT instance determines **how much traffic can be handled**
- **High availability** can be achieved using **Autoscaling Groups**, multiple **subnets in different AZs**, and **automate failover between them using a scrip**t.

- NAT Gateways are **redundant inside an Availability Zone** (can survive failure of EC2 instance)
- You can only have **1 NAT Gateway inside 1 Availability Zone** (cannot span AZs)
- Starts at 5 Gbps and scales all the way up to 45 Gbps
- NAT Gateways are the **preferred setup for enterprise systems**.
- There is no **requirement to patch NAT Gateways**, and there is no **need to disable Source/Destination checks** for the NAT Gateway (unlike NAT Instances)
- NAT Gateways are **automatically assigned a public IP address**
- **Route Tables** for the NAT Gateway MUST be updated
- Resources in multiple AZs sharing a Gateway will **lose internet access if the Gateway** goes down, unless you create a **Gateway in each AZ** and configure **route tables** accordingly

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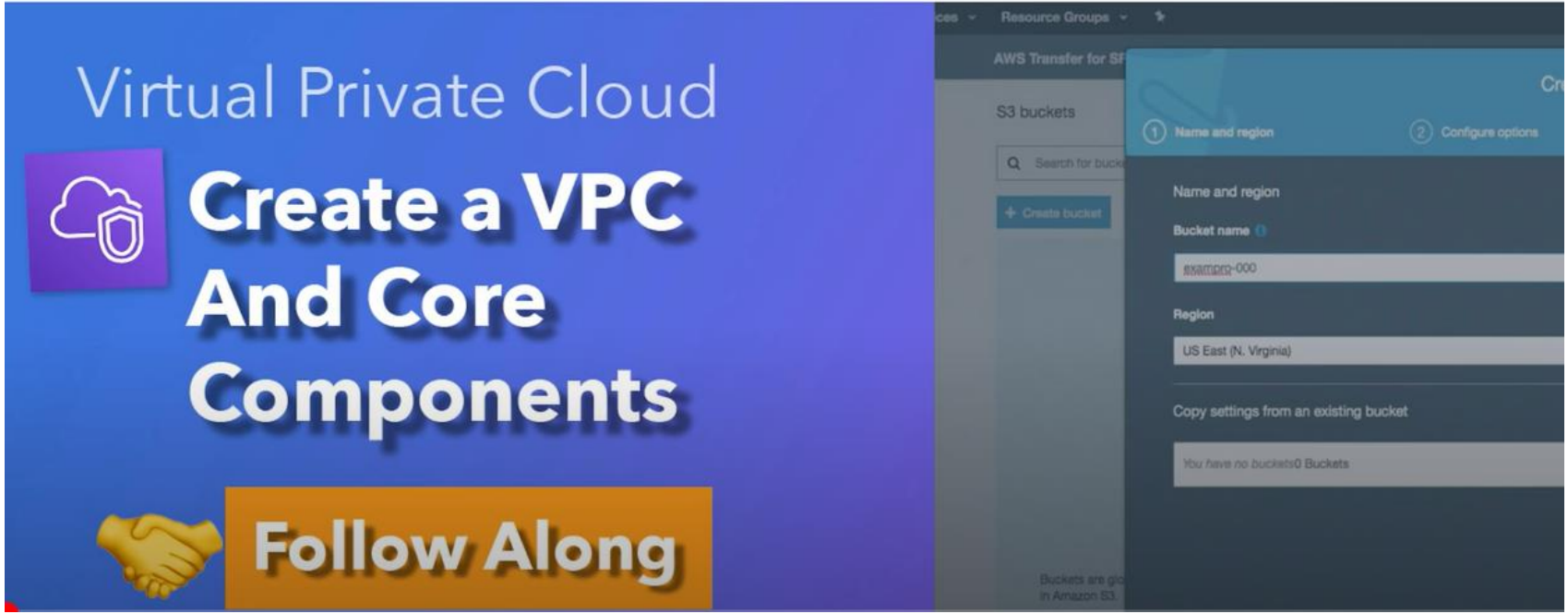

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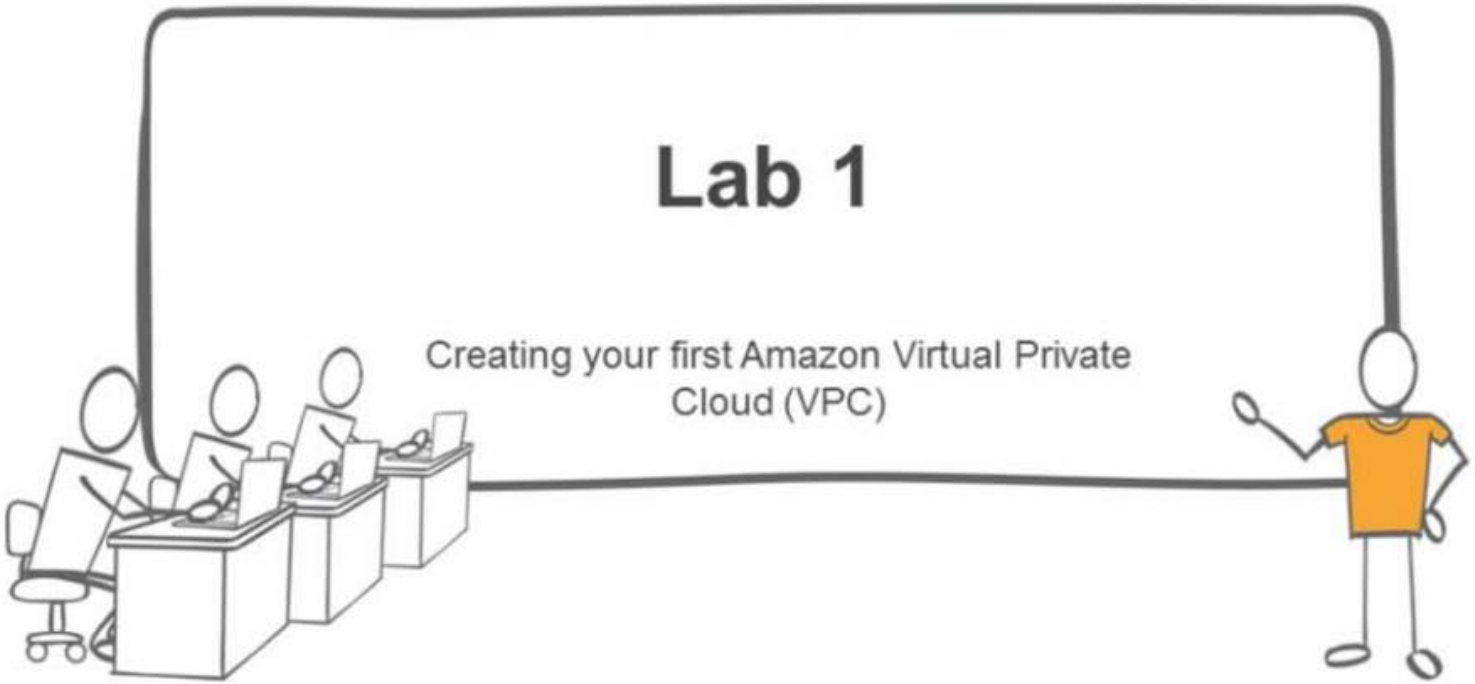
Lab 1

Creating your first Amazon Virtual Private Cloud (VPC)



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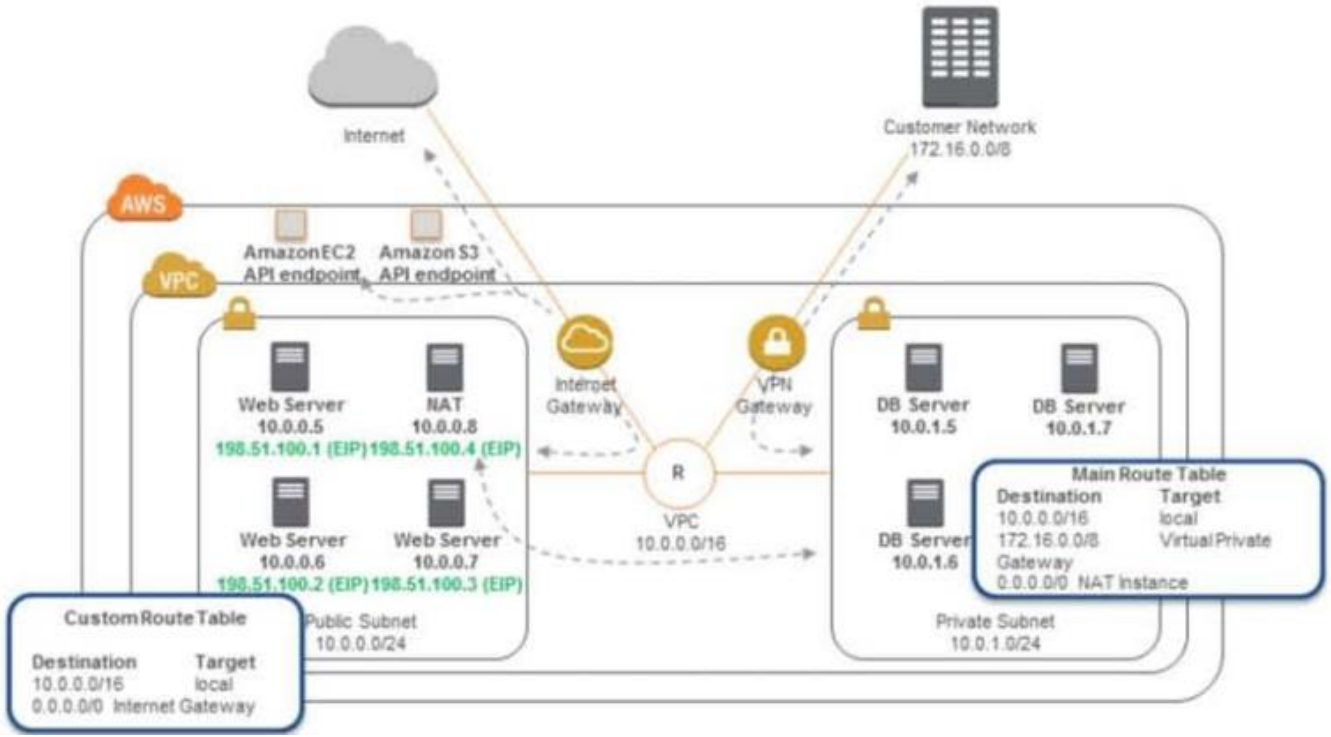
Appendix

Appendix


Internet
Customer Network
172.16.0.0/8
AWS
VPC
Amazon EC2
API endpoint
Amazon S3
API endpoint
Web Server
10.0.0.5
198.51.100.1 (EIP)
NAT
10.0.0.8
198.51.100.4 (EIP)
Web Server
10.0.0.6
198.51.100.2 (EIP)
Web Server
10.0.0.7
198.51.100.3 (EIP)
Public Subnet
10.0.0.0/24
Internet
Gateway
R
VPC
10.0.0.0/16
VPN
Gateway
DB Server
10.0.1.5
DB Server
10.0.1.7
DB Server
10.0.1.6
Private Subnet
10.0.1.0/24
Main Route Table
Destination
Target
10.0.0.0/16
local
172.16.0.0/8
Virtual Private
Gateway
0.0.0.0/0
NAT Instance
Custom Route Table
Destination
Target
10.0.0.0/16
local
0.0.0.0/0
Internet Gateway