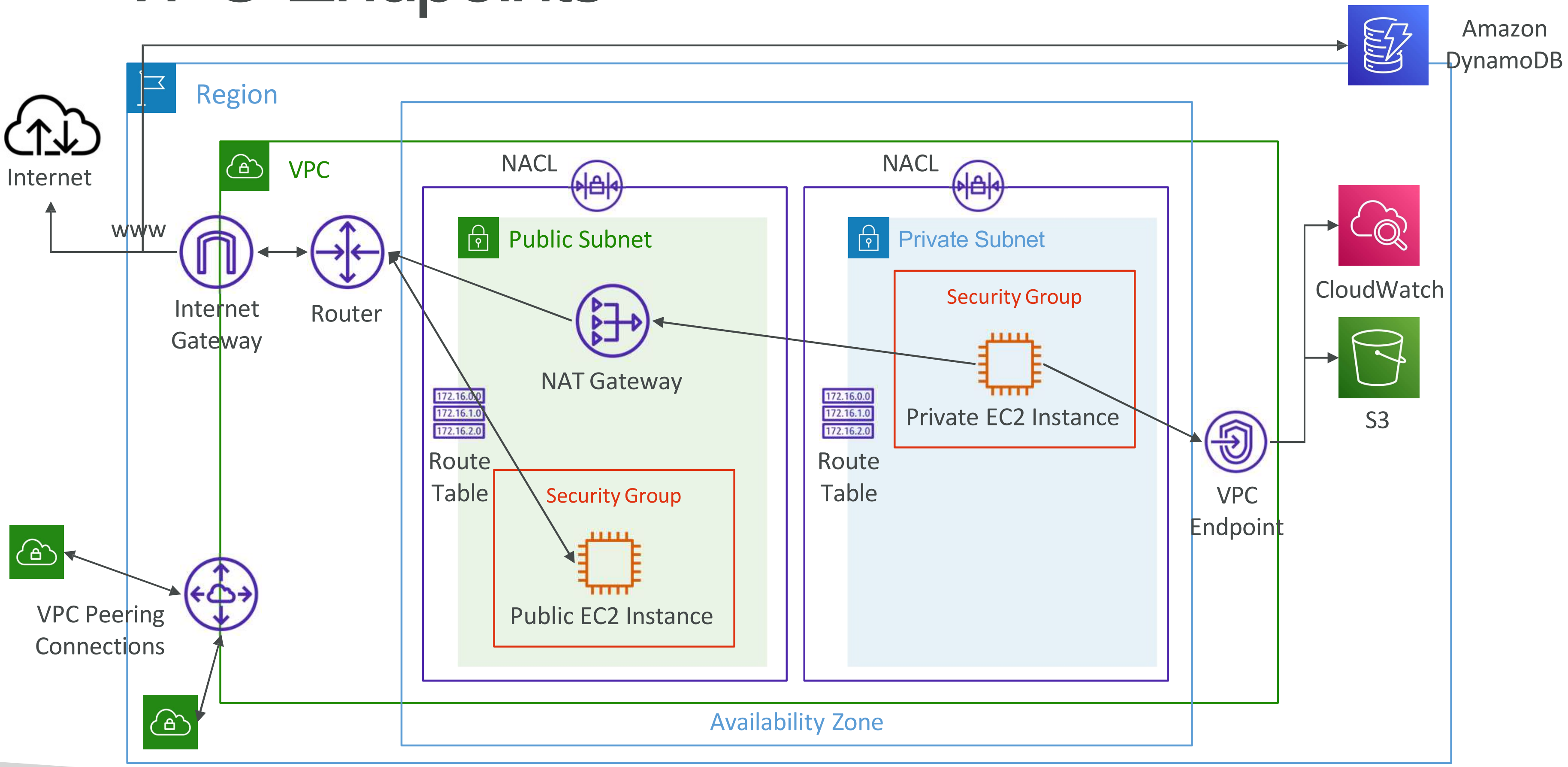
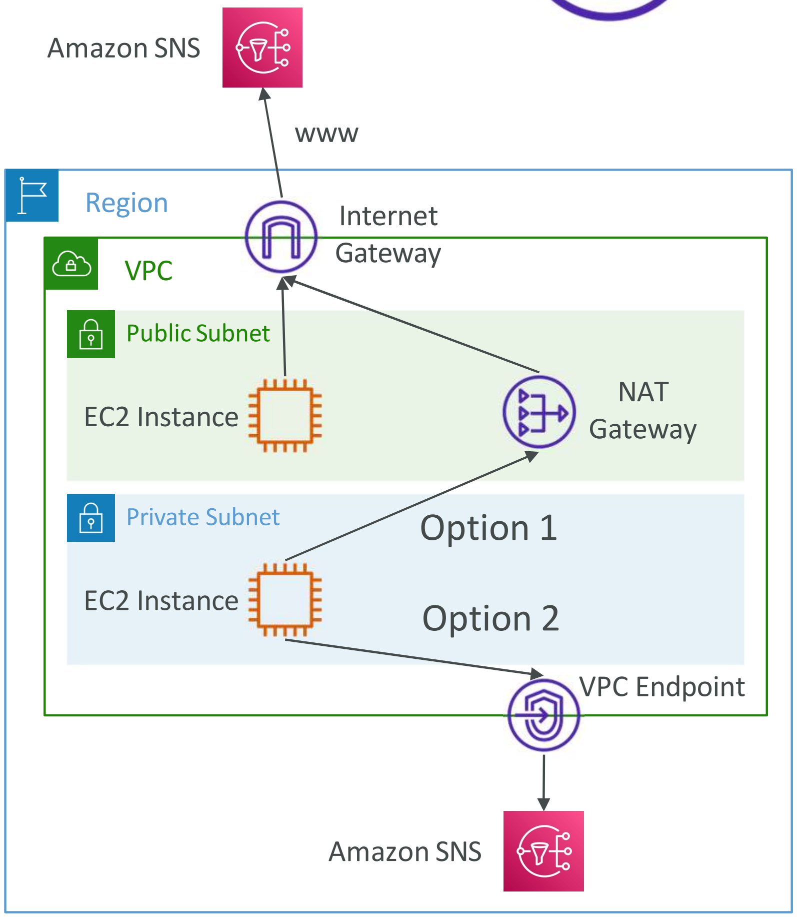
Amazon Networking VPC - Part 2

VPC Endpoints



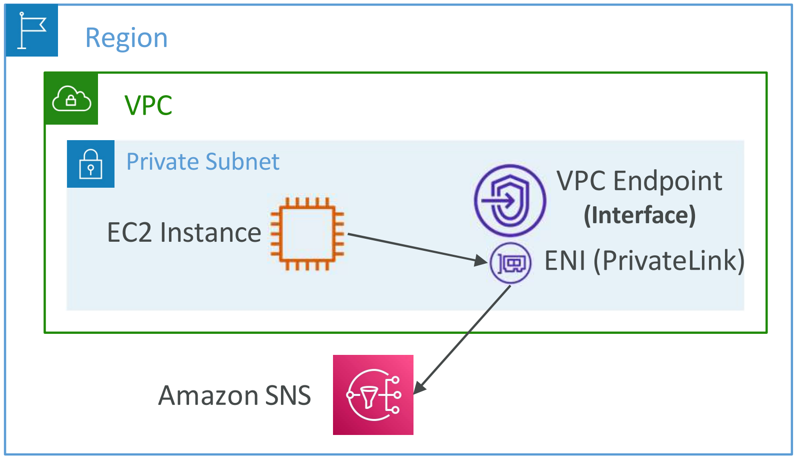
VPC Endpoints (AWS PrivateLink)

- Every AWS service is publicly exposed (public URL)
- VPC Endpoints (powered by AWS PrivateLink) allows you to connect to AWS services using a private network instead of using the public Internet
- They're redundant and scale horizontally
- They remove the need of IGW, NATGW, … to access AWS Services
- In case of issues:
  - Check DNS Setting Resolution in your VPC
  - Check Route Tables

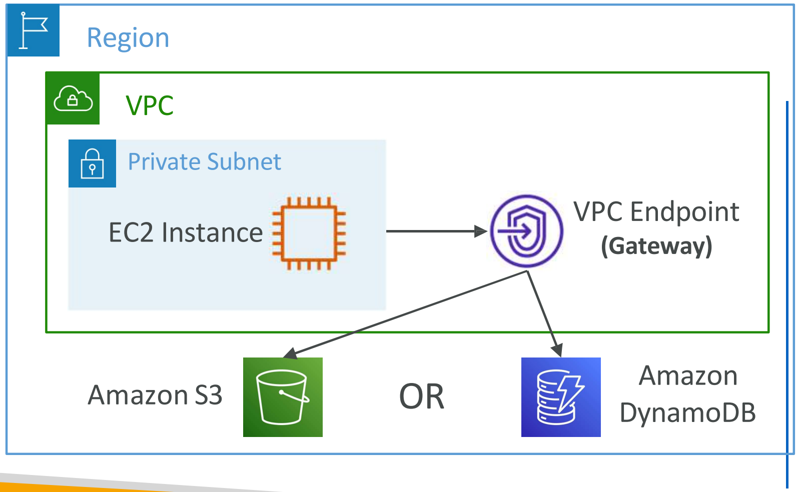


Types of Endpoints

- Interface Endpoints (powered by PrivateLink)
  - Provisions an ENI (private IP address) as an entry point (must attach a Security Group)
  - Supports most AWS services
  - $ per hour + $ per GB of data processed

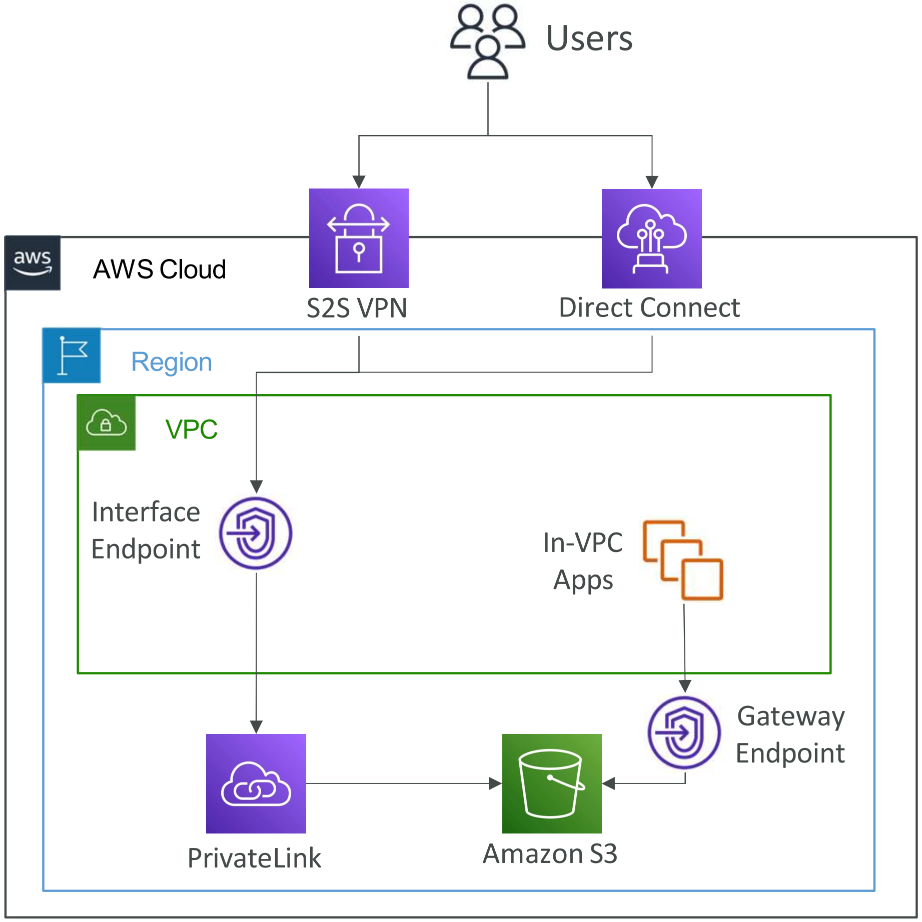


- Gateway Endpoints
  - Provisions a gateway and must be used as a target in a route table (does not use security groups)
  - Supports both S3 and DynamoDB
  - Free



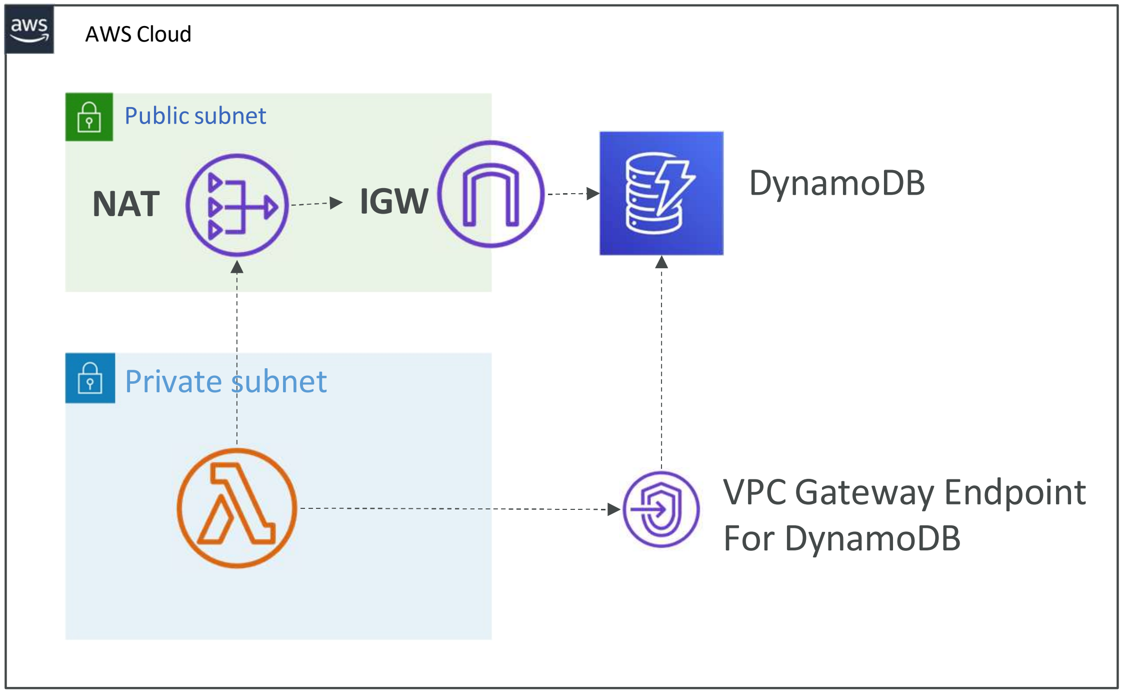
Gateway or Interface Endpoint for S3?

- Gateway is most likely going to be preferred all the time at the exam
- Cost: free for Gateway, $ for interface endpoint
- Interface Endpoint is preferred access is required from on-premises (Site to Site VPN or Direct Connect), a different VPC or a different region



Lambda in VPC accessing DynamoDB

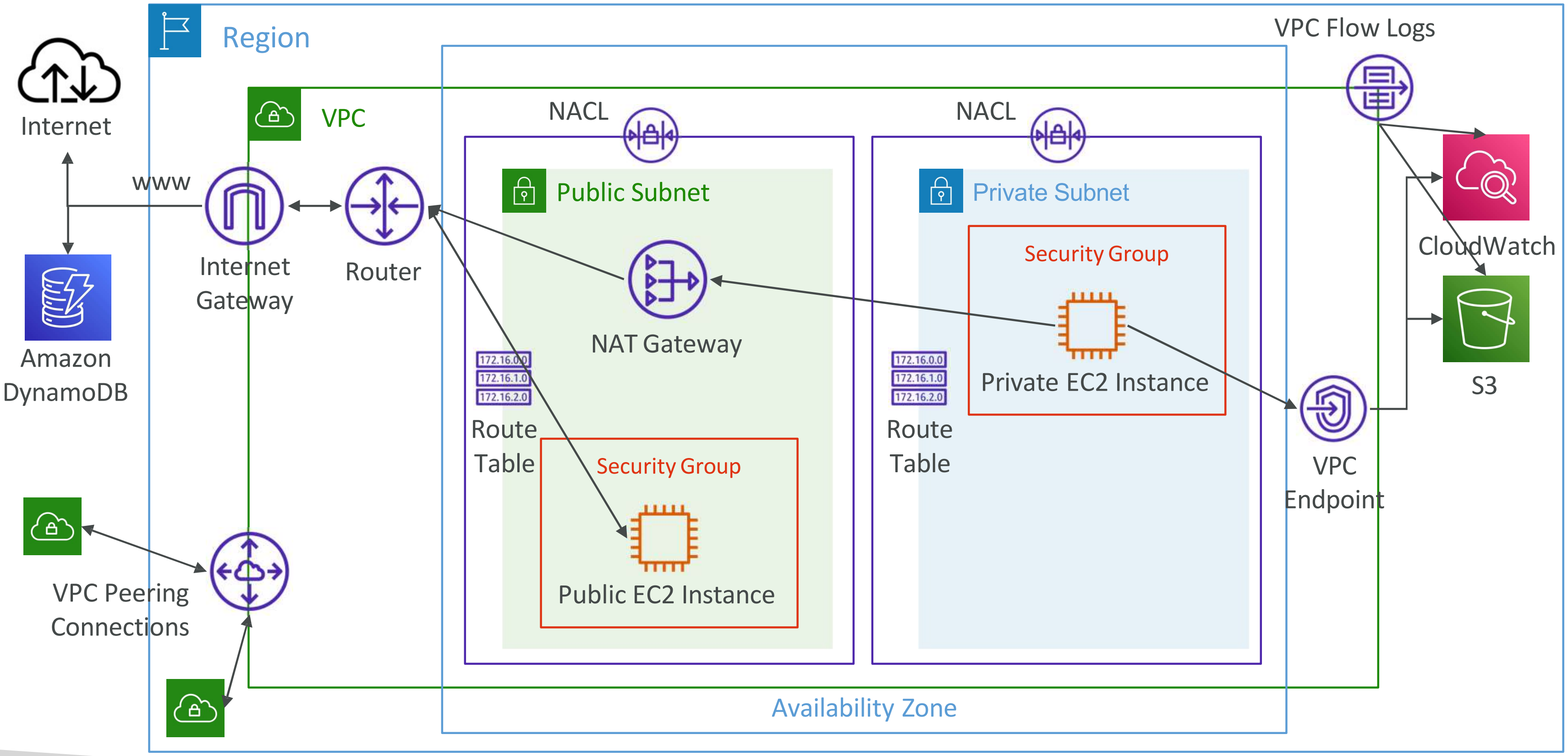
- DynamoDB is a public service from AWS
- Option 1: Access from the public internet
  - Because Lambda is in a VPC, it needs a NAT Gateway in a public subnet and an internet gateway
- Option 2 (better & free): Access from the private VPC network
  - Deploy a VPC Gateway endpoint for DynamoDB
  - Change the Route Tables



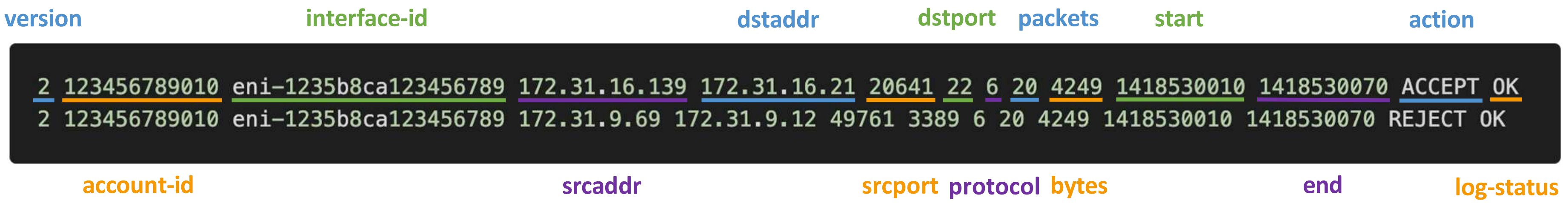
VPC Flow Logs

- Capture information about IP traffic going into your interfaces:
  - VPC Flow Logs
  - Subnet Flow Logs
  - Elastic Network Interface (ENI) Flow Logs
- Helps to monitor & troubleshoot connectivity issues
- Flow logs data can go to S3, CloudWatch Logs, and Kinesis Data Firehose
- Captures network information from AWS managed interfaces too: ELB, RDS, ElastiCache, Redshift, WorkSpaces, NATGW, Transit Gateway…

VPC Flow Logs



VPC Flow Logs Syntax



```
2 123456789010 eni-1235b8ca123456789 172.31.16.139 172.31.16.21 20641 22 6 20 4249 1418530010 1418530070 ACCEPT OK
2 123456789010 eni-1235b8ca123456789 172.31.9.69 172.31.9.12 49761 3389 6 20 4249 1418530010 1418530070 REJECT OK
```

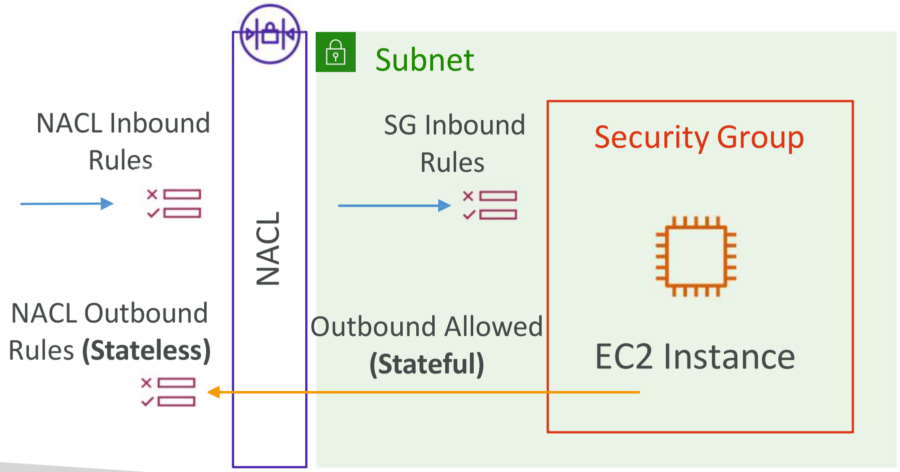
- srcaddr & dstaddr – help identify problematic IP
- srcport & dstport – help identity problematic ports
- Action – success or failure of the request due to Security Group / NACL
- Can be used for analytics on usage patterns, or malicious behavior
- Query VPC flow logs using Athena on S3 or CloudWatch Logs Insights
- Flow Logs examples: https://docs.aws.amazon.com/vpc/latest/userguide/flow-logs-records-examples.html

VPC Flow Logs - Troubleshoot SG & NACL issues

Look at the **"ACTION"** field

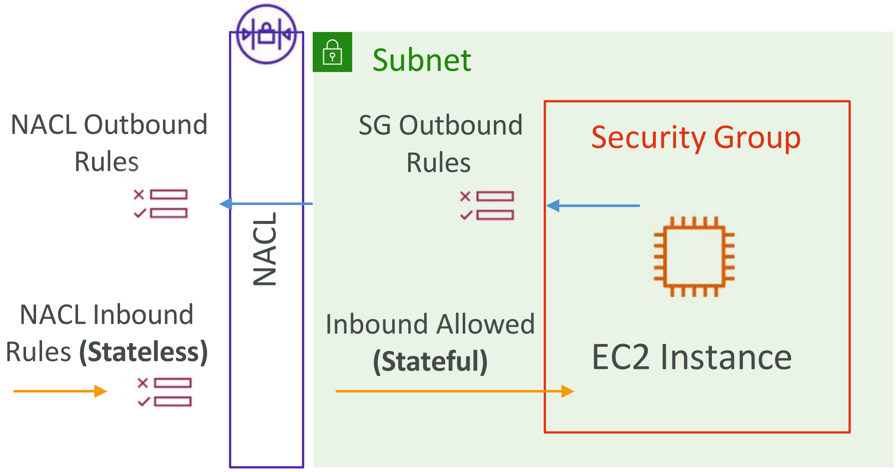
Incoming Requests

- Inbound REJECT => NACL or SG
- Inbound ACCEPT, Outbound REJECT => NACL

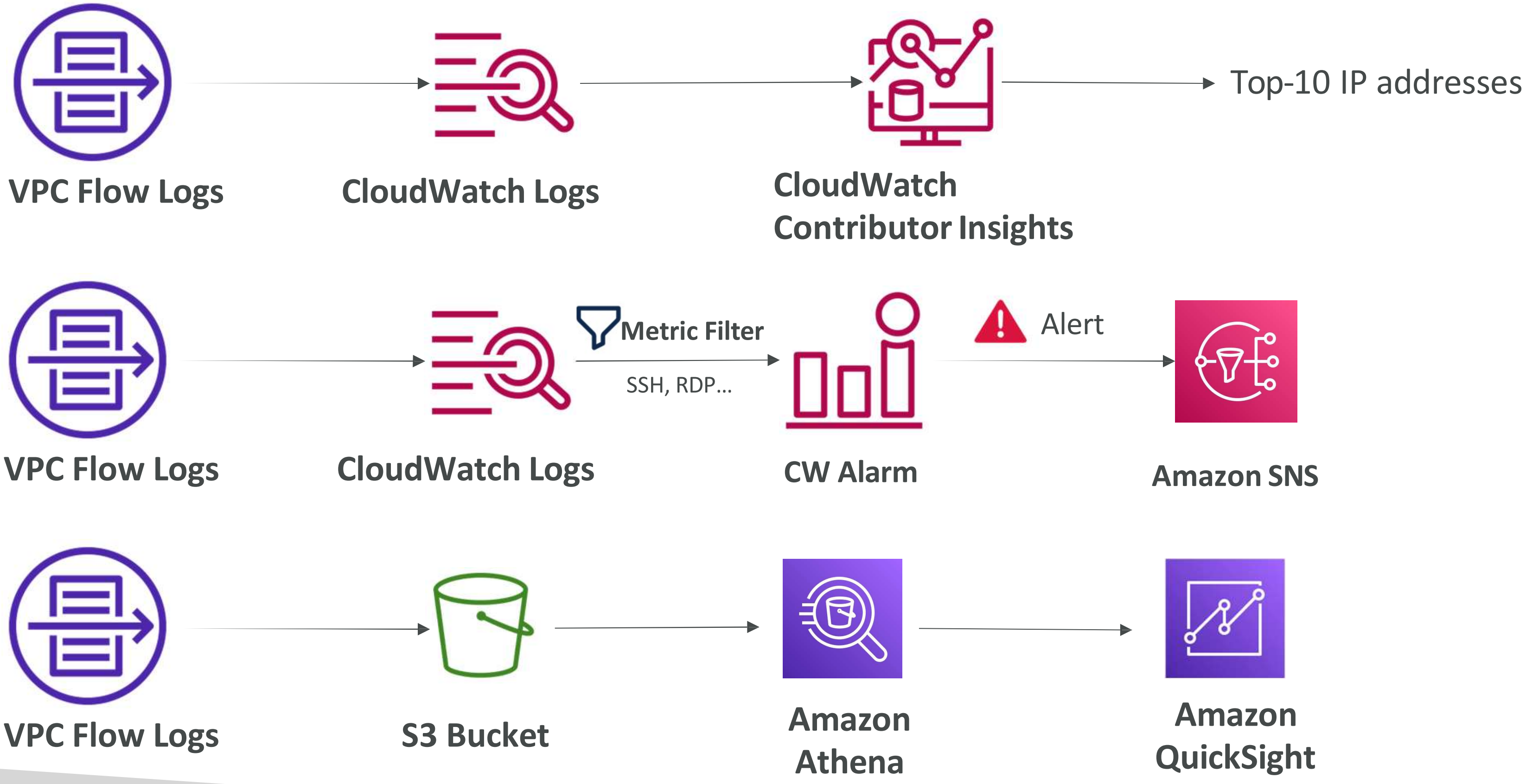


Outgoing Requests

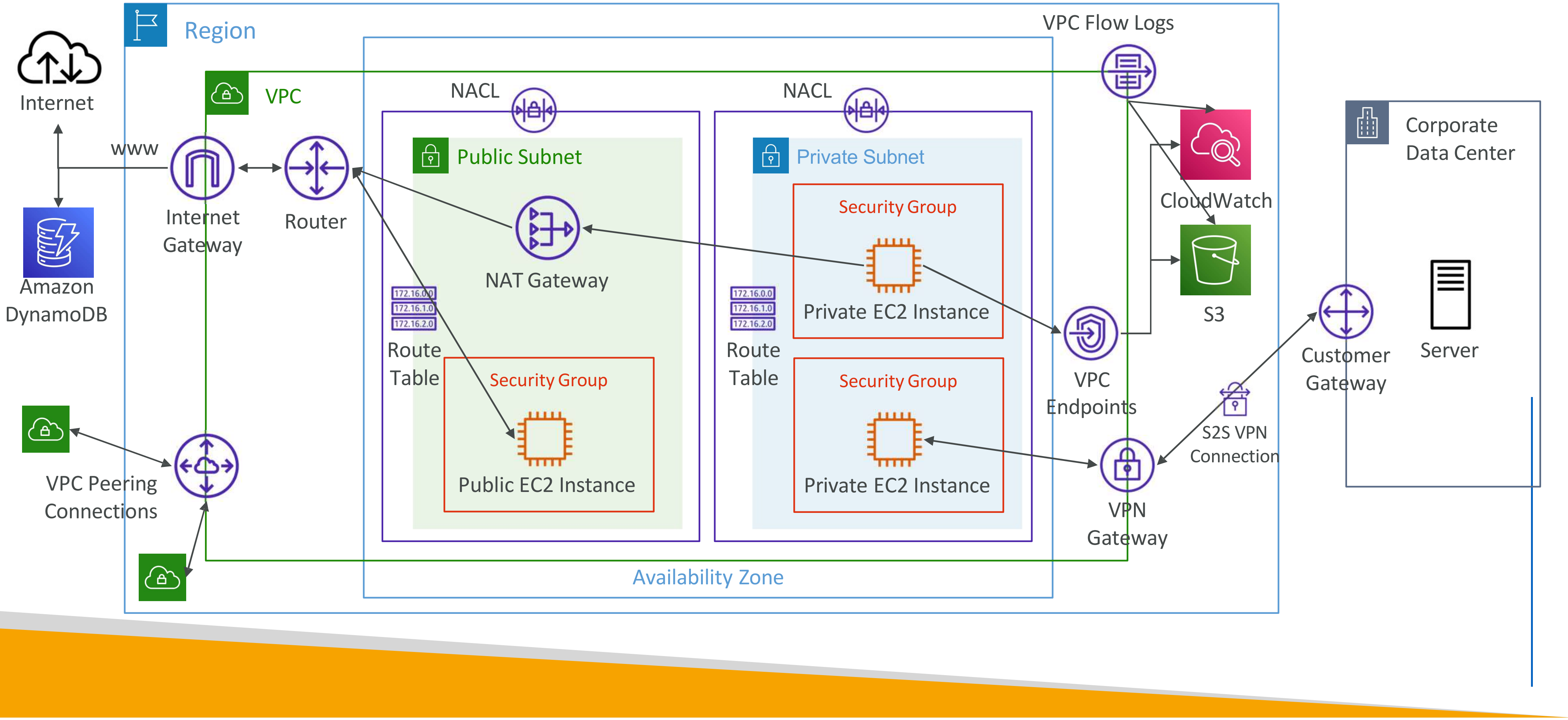
- Outbound REJECT => NACL or SG
- Outbound ACCEPT, Inbound REJECT => NACL



VPC Flow Logs - Architectures



AWS Site-to-Site VPN



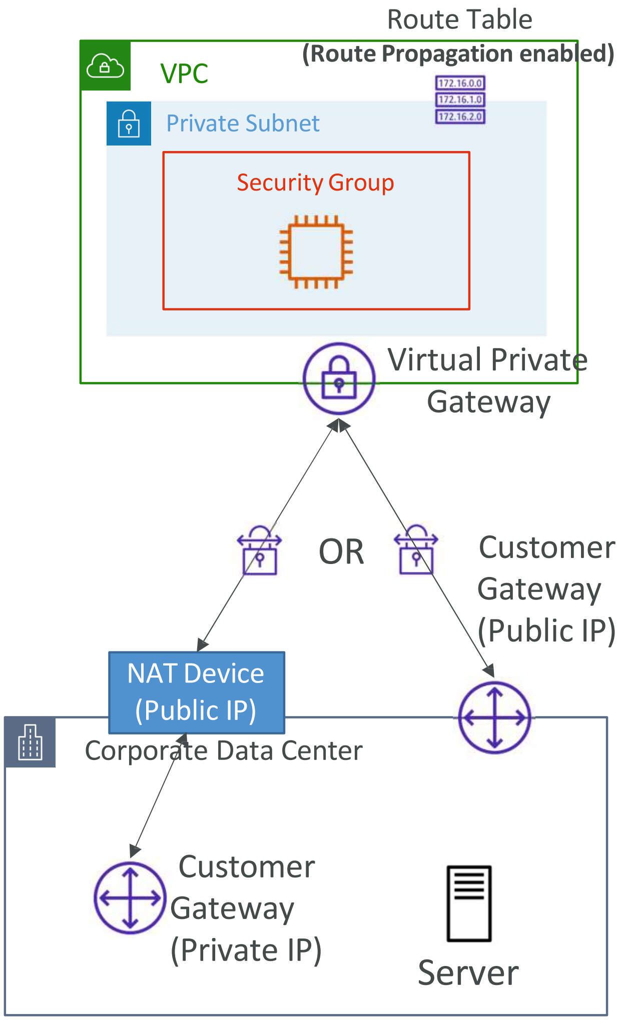
AWS Site-to-Site VPN

- Virtual Private Gateway (VGW)
  - VPN concentrator on the AWS side of the VPN connection
  - VGW is created and attached to the VPC from which you want to create the Site-to-Site VPN connection
  - Possibility to customize the ASN (Autonomous System Number)

- Customer Gateway (CGW)
  - Software application or physical device on customer side of the VPN connection
  - https://docs.aws.amazon.com/vpn/latest/s2svpn/your-cgw.html#DevicesTested

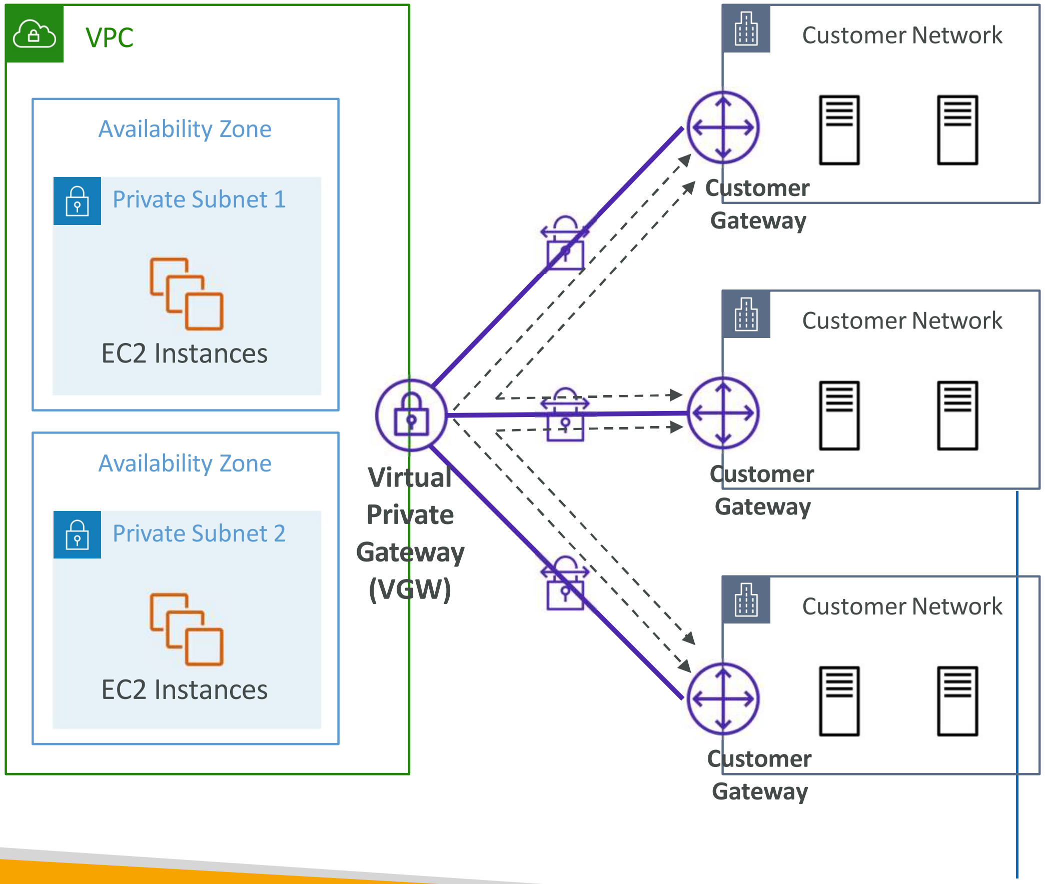
Site-to-Site VPN Connections

- Customer Gateway Device (On-premises)
  - What IP address to use?
    - Public Internet-routable IP address for your Customer Gateway device
    - If it's behind a NAT device that's enabled for NAT traversal (NAT-T), use the public IP address of the NAT device
- Important step: enable Route Propagation for the Virtual Private Gateway in the route table that is associated with your subnets
- If you need to ping your EC2 instances from on-premises, make sure you add the ICMP protocol on the inbound of your security groups



AWS VPN CloudHub

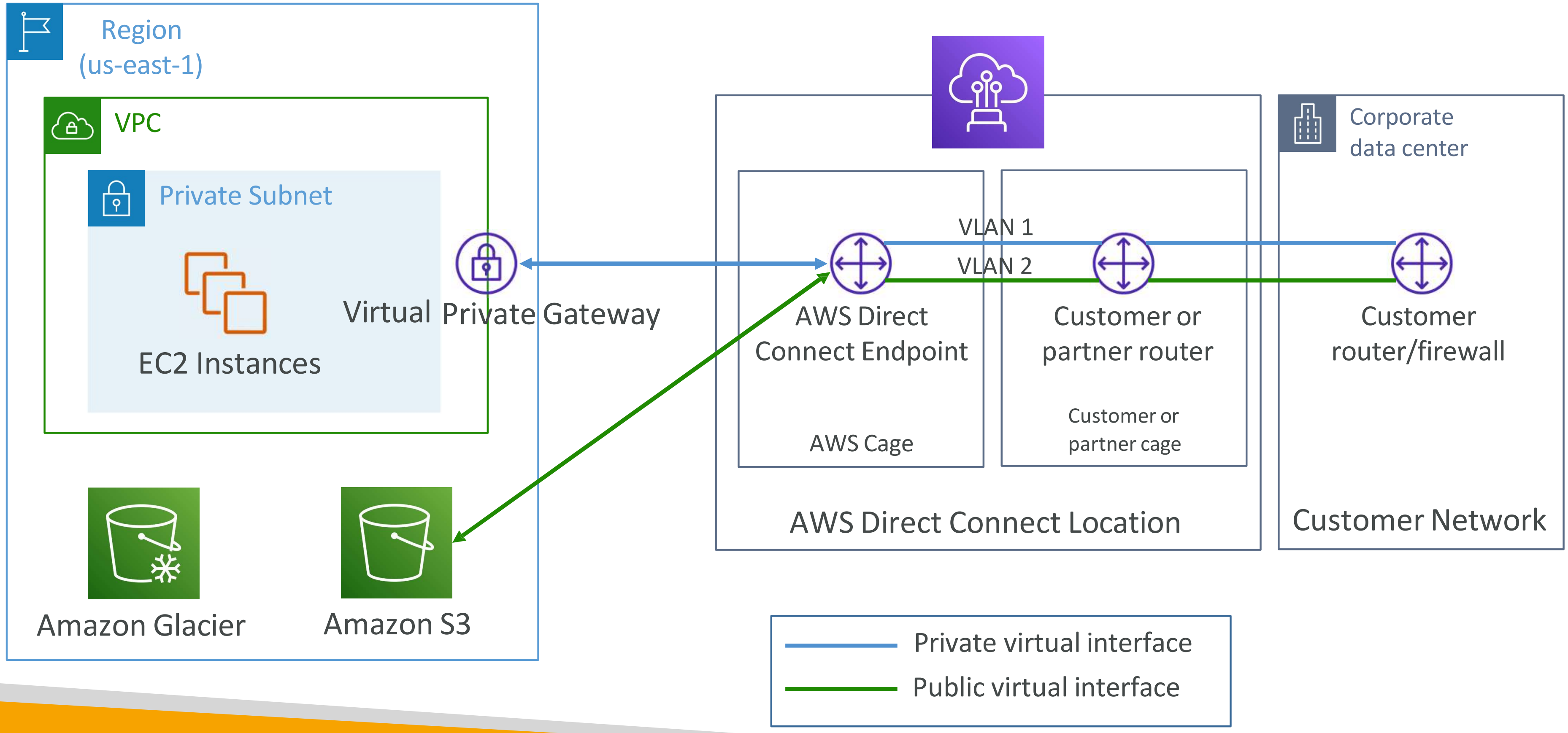
- Provide secure communication between multiple sites, if you have multiple VPN connections
- Low-cost hub-and-spoke model for primary or secondary network connectivity between different locations (VPN only)
- It's a VPN connection so it goes over the public Internet
- To set it up, connect multiple VPN connections on the same VGW, setup dynamic routing and configure route tables



Direct Connect (DX)

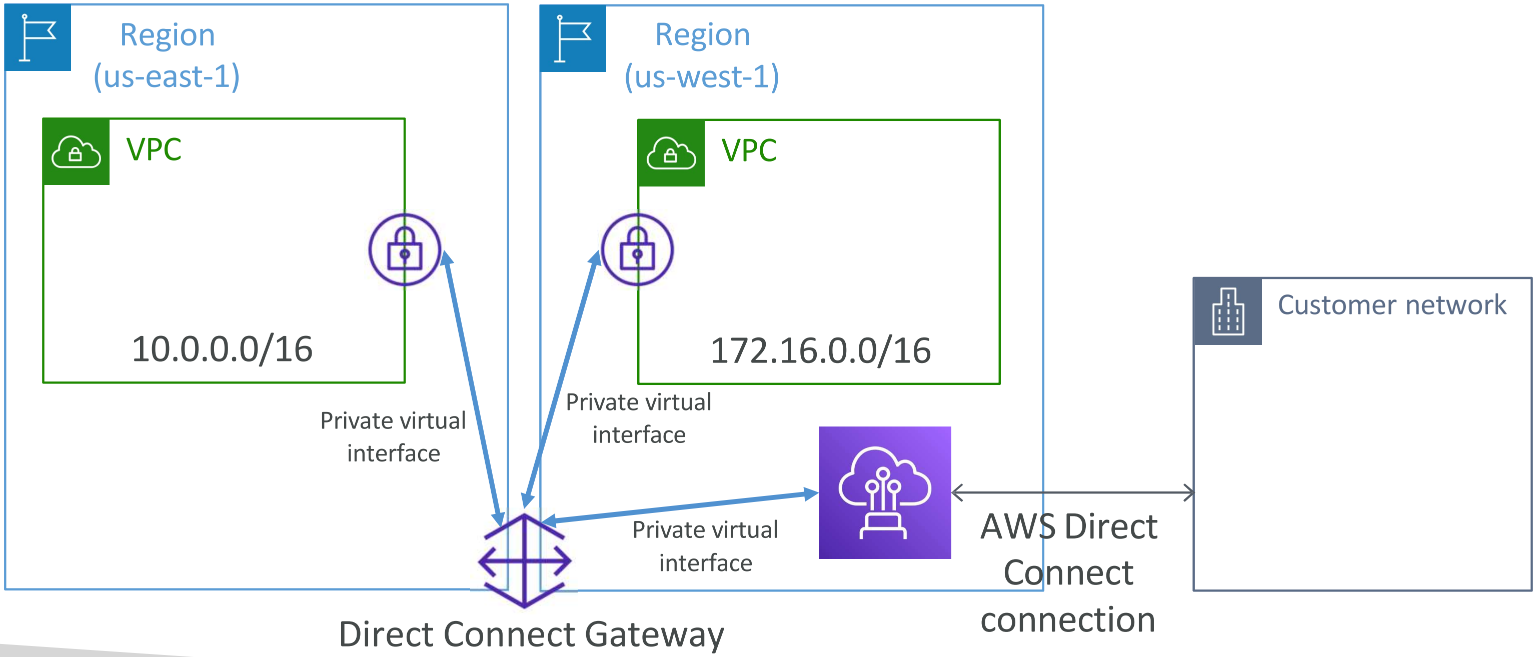
- Provides a dedicated <u>private</u> connection from a remote network to your VPC
- Dedicated connection must be setup between your DC and AWS Direct Connect locations
- You need to setup a Virtual Private Gateway on your VPC
- Access public resources (S3) and private (EC2) on same connection
- Use Cases:
  - Increase bandwidth throughput - working with large data sets - lower cost
  - More consistent network experience - applications using real-time data feeds
  - Hybrid Environments (on prem + cloud)
- Supports both IPv4 and IPv6

Direct Connect Diagram



Direct Connect Gateway

- If you want to setup a Direct Connect to one or more VPC in many different regions (same account), you must use a Direct Connect Gateway


Region
(us-east-1)
VPC
10.0.0.0/16
Private virtual interface
Region
(us-west-1)
VPC
172.16.0.0/16
Private virtual interface
Private virtual interface
AWS Direct Connect connection
Customer network
Direct Connect Gateway

Direct Connect - Connection Types

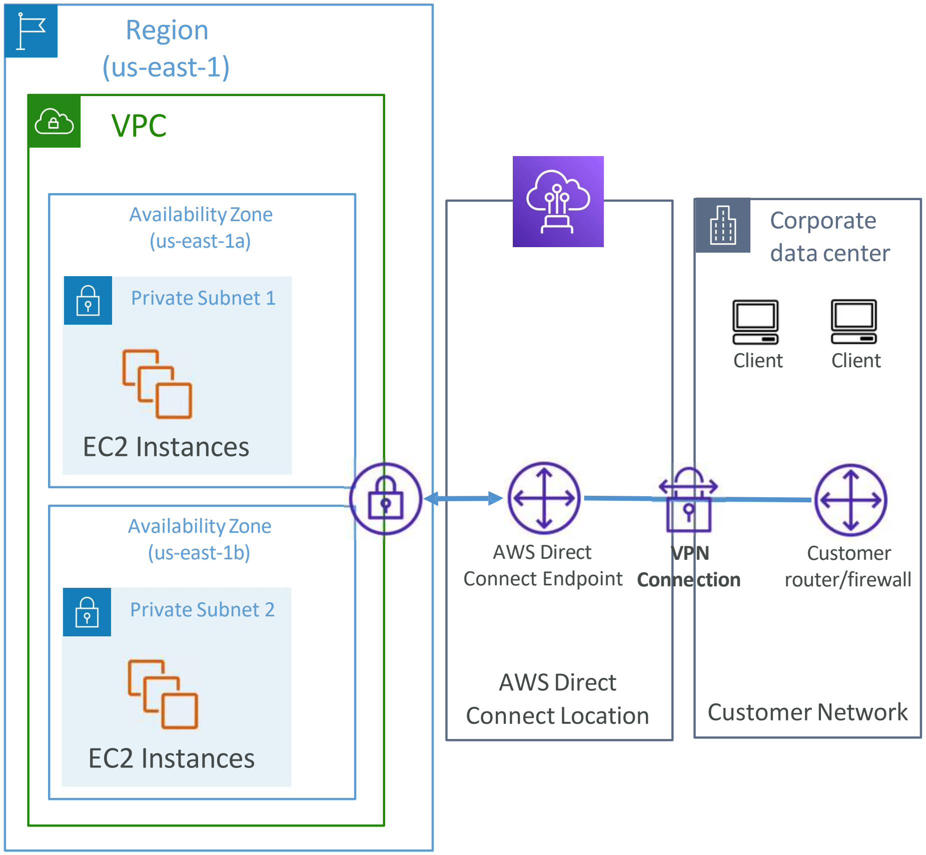
- Dedicated Connections: 1Gbps,10 Gbps and 100 Gbps capacity
  - Physical ethernet port dedicated to a customer
  - Request made to AWS first, then completed by AWS Direct Connect Partners

- Hosted Connections: 50Mbps, 500 Mbps, to 10 Gbps
  - Connection requests are made via AWS Direct Connect Partners
  - Capacity can be added or removed on demand
  - 1, 2, 5, 10 Gbps available at select AWS Direct Connect Partners

- Lead times are often longer than 1 month to establish a new connection

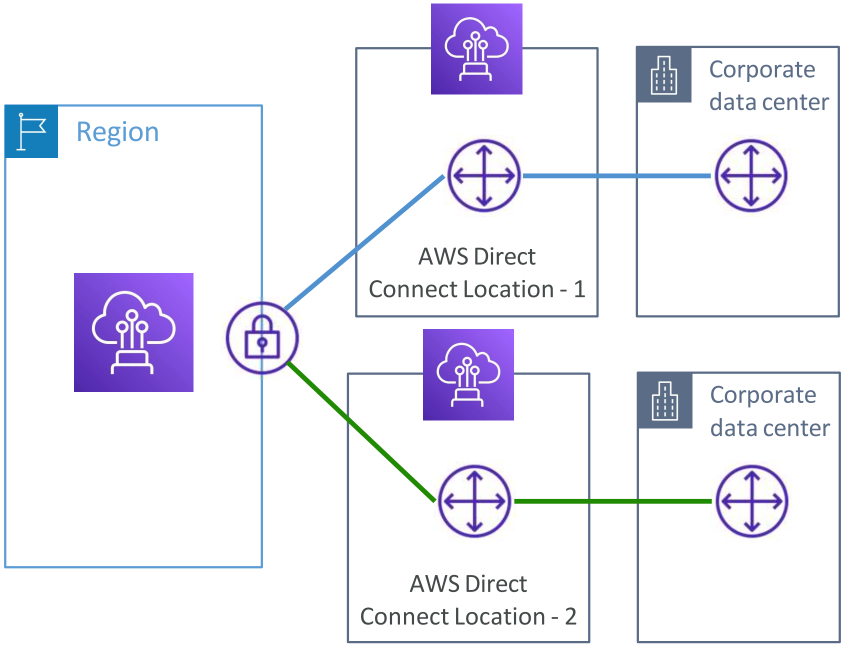
Direct Connect - Encryption

- Data in transit is not encrypted but is private
- AWS Direct Connect + VPN provides an IPsec-encrypted private connection
- Good for an extra level of security, but slightly more complex to put in place



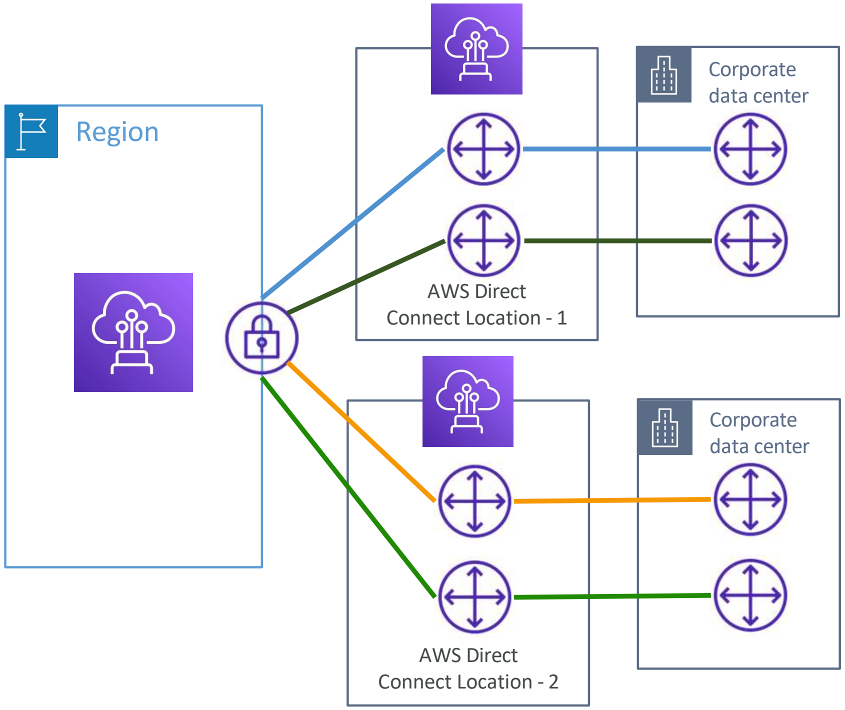
Direct Connect - Resiliency

High Resiliency for Critical Workloads


Region
AWS Direct Connect Location - 1
Corporate data center
AWS Direct Connect Location - 2
Corporate data center

One connection at multiple locations

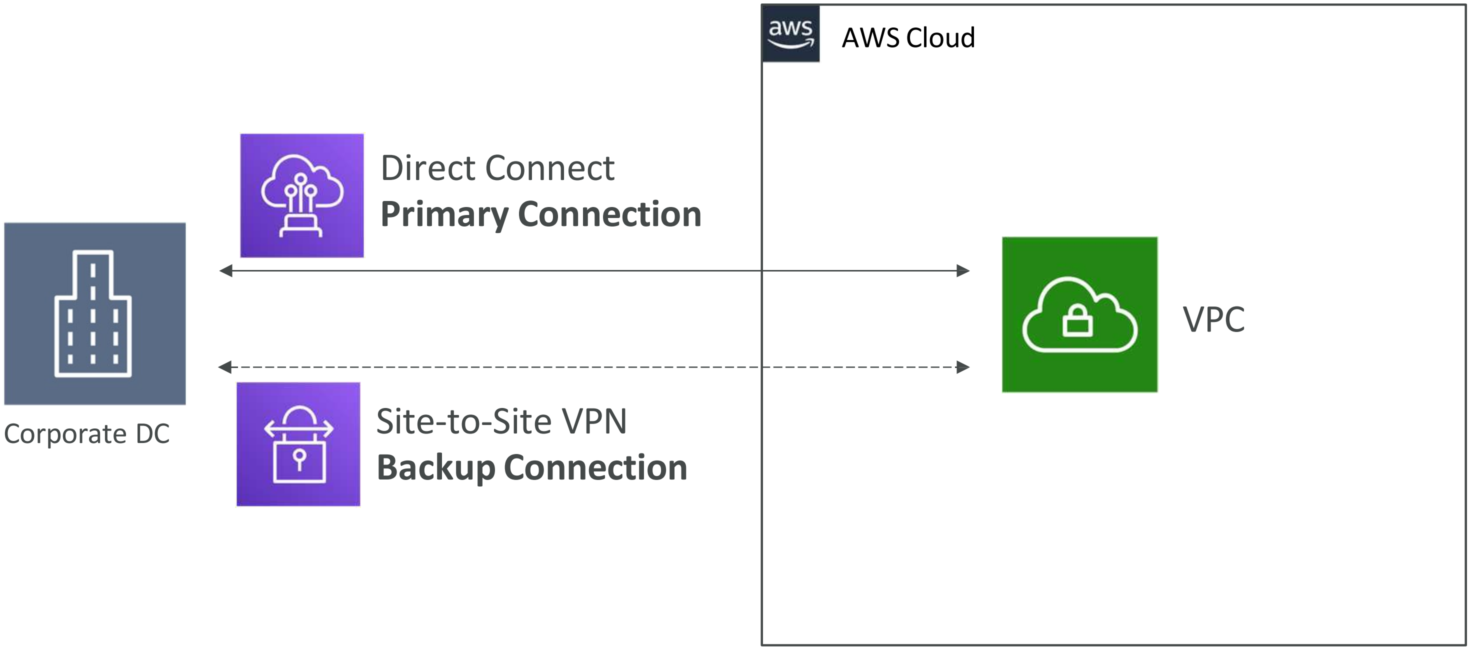
Maximum Resiliency for Critical Workloads


Region
AWS Direct Connect Location - 1
Corporate data center
AWS Direct Connect Location - 2
Corporate data center

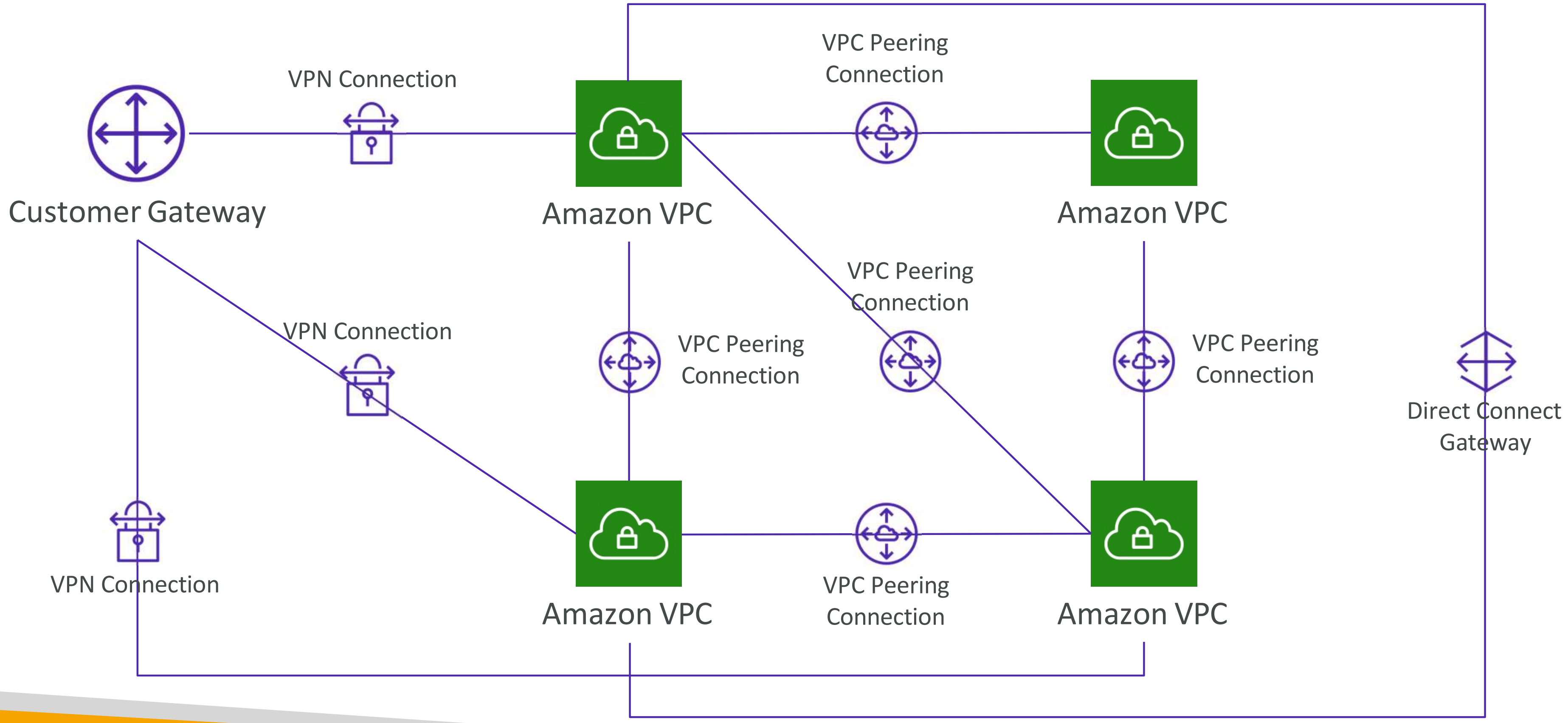
Maximum resilience is achieved by separate connections terminating on separate devices in more than one location.

Site-to-Site VPN connection as a backup

- In case Direct Connect fails, you can set up a backup Direct Connect connection (expensive), or a Site-to-Site VPN connection

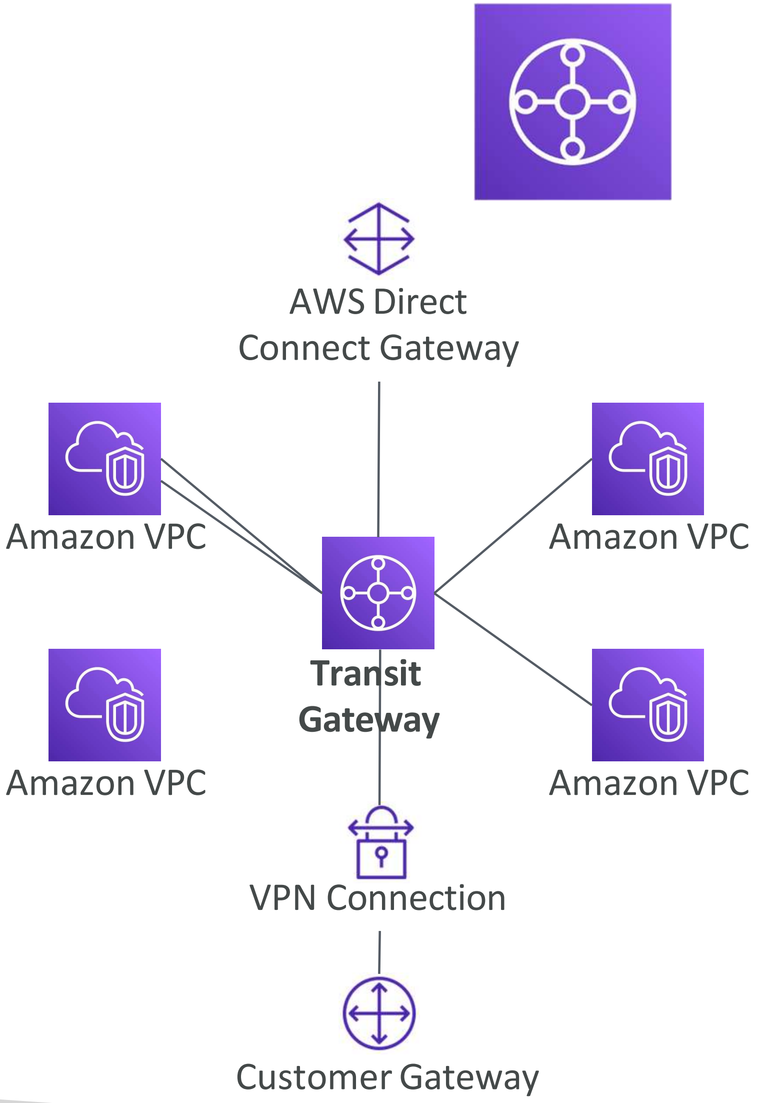


Network topologies can become complicated



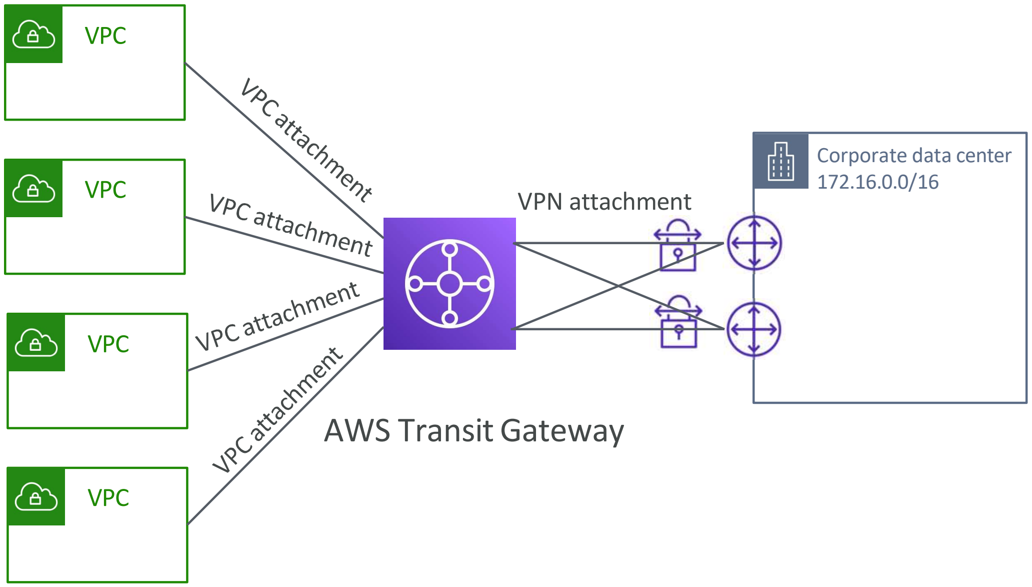
Transit Gateway

- For having transitive peering between thousands of VPC and on-premises, hub-and-spoke (star) connection
- Regional resource, can work cross-region
- Share cross-account using Resource Access Manager (RAM)
- You can peer Transit Gateways across regions
- Route Tables: limit which VPC can talk with other VPC
- Works with Direct Connect Gateway, VPN connections
- Supports IP Multicast (not supported by any other AWS service)



Transit Gateway: Site-to-Site VPN ECMP

- ECMP = Equal-cost multi-path routing
- Routing strategy to allow to forward a packet over multiple best path
- Use case: create multiple Site-to-Site VPN connections to increase the bandwidth of your connection to AWS



Transit Gateway: throughput with ECMP

VPN to virtual private gateway

1x = 1x VPC

1x = 1.25 Gbps

VPN connection
(2 tunnels)

VPN to transit gateway

1x = 1x VPC VPC VPC VPC

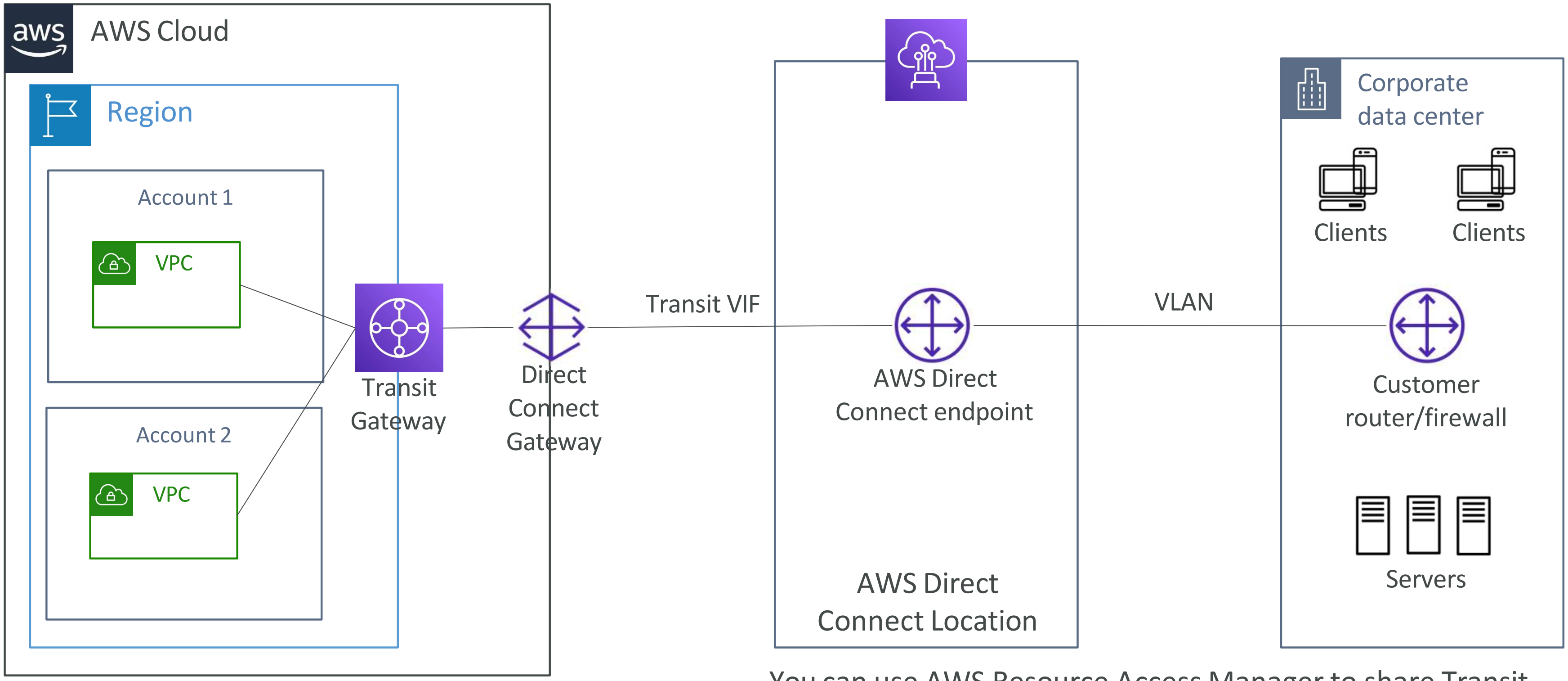
1x = 2.5 Gbps (ECMP) – 2 tunnels used

2x = 5.0 Gbps (ECMP)

3x = 7.5 Gbps (ECMP)

+$$ per GB of TGW processed data

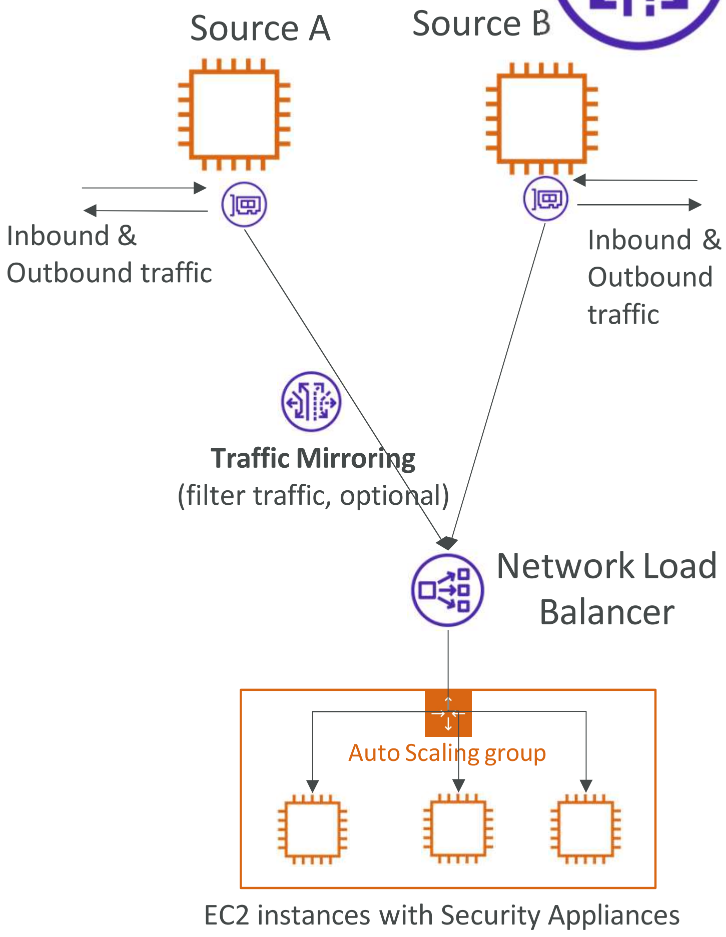
Transit Gateway - Share Direct Connect between multiple accounts



You can use AWS Resource Access Manager to share Transit Gateway with other accounts.

VPC - Traffic Mirroring

- Allows you to capture and inspect network traffic in your VPC
- Route the traffic to security appliances that you manage
- Capture the traffic
  - From (Source) - ENIs
  - To (Targets) - an ENI or a Network Load Balancer
- Capture all packets or capture the packets of your interest (optionally, truncate packets)
- Source and Target can be in the same VPC or different VPCs (VPC Peering)
- Use cases: content inspection, threat monitoring, troubleshooting, …


Source A
Source B
Inbound & Outbound traffic
Inbound & Outbound traffic
Traffic Mirroring
(filter traffic, optional)
Network Load Balancer
Auto Scaling group
EC2 instances with Security Appliances

What is IPv6?

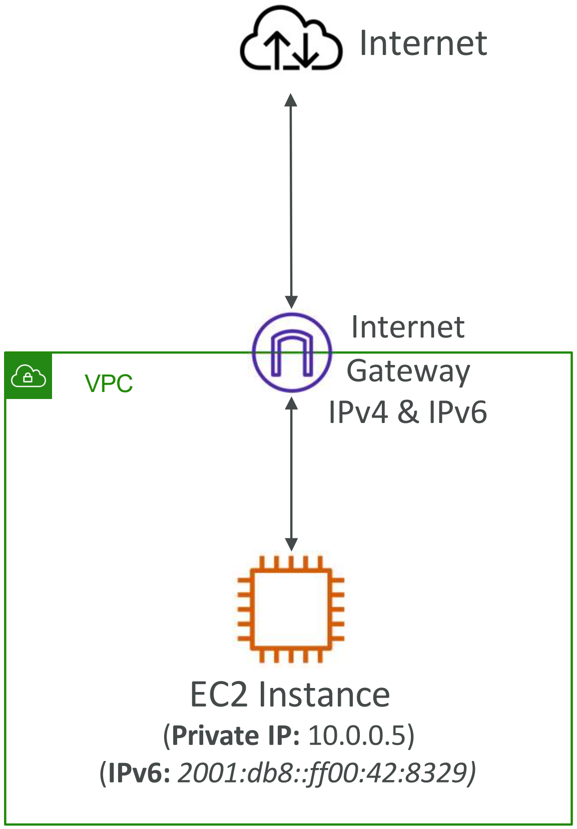
- IPv4 designed to provide 4.3 Billion addresses (they’ll be exhausted soon)

- IPv6 is the successor of IPv4
- IPv6 is designed to provide 3.4×10,- unique IP addresses
- Every IPv6 address <u>in AWS</u> is public and Internet-routable (no private range)
- Format -+ x.x.x.x.x.x.x.x (<u>x</u> is hexadecimal, range can be from 0000 to ffff)
- Examples:
  - 2001:db8:3333:4444:5555:6666:7777:8888
  - 2001:db8:3333:4444:cccc:dddd:eeee:ffff
  - :: - + all 8 segments are zero
  - 2001:db8:: - + the last 6 segments are zero
  - ::1234:5678 - + the first 6 segments are zero
  - 2001:db8::1234:5678 - + the middle 4 segments are zero

IPv6 in VPC

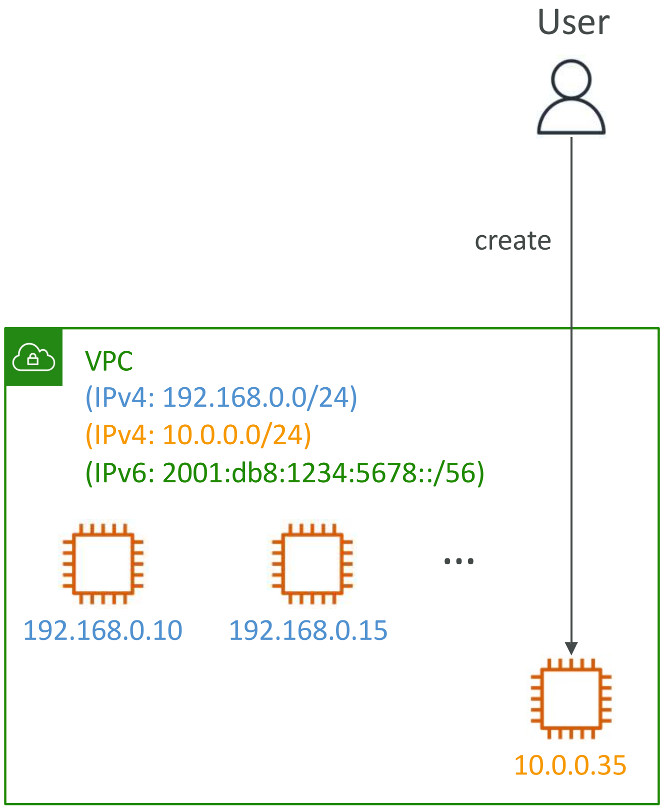
- IPv4 cannot be disabled for your VPC and subnets
- You can enable IPv6 (they're public IP addresses) to operate in dual-stack mode

- Your EC2 instances will get at least a private internal IPv4 and a public IPv6
- They can communicate using either IPv4 or IPv6 to the internet through an Internet Gateway


Internet
Internet Gateway IPv4 & IPv6
VPC
EC2 Instance
(**Private IP:** 10.0.0.5)
(**IPv6:** *2001:db8::ff00:42:8329)*

IPv6 Troubleshooting

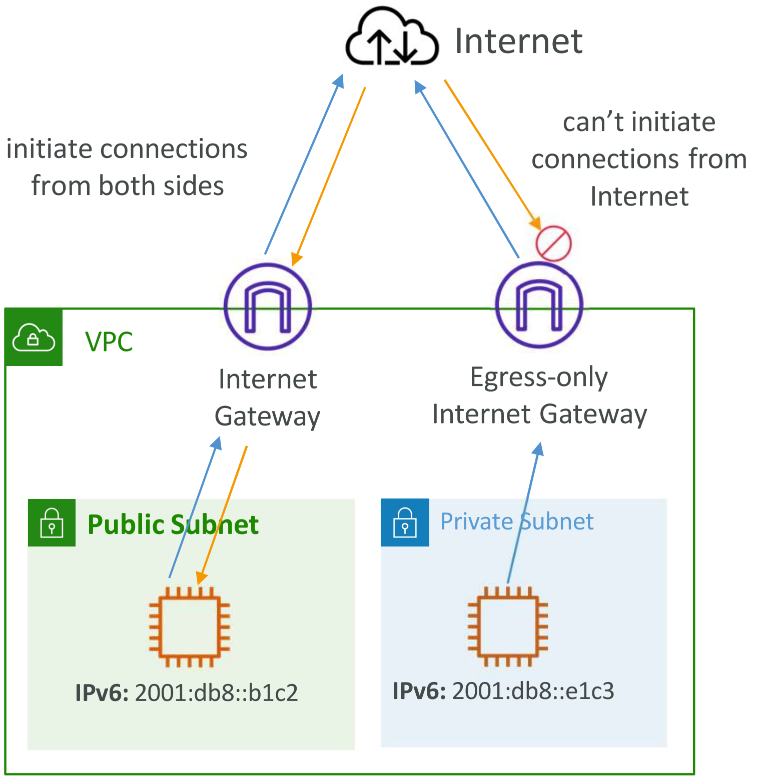
- IPv4 cannot be disabled for your VPC and subnets
- So, if you cannot launch an EC2 instance in your subnet
  - It's not because it cannot acquire an IPv6 (the space is very large)
  - It's because there are no available IPv4 in your subnet
- Solution: create a new IPv4 CIDR in your subnet



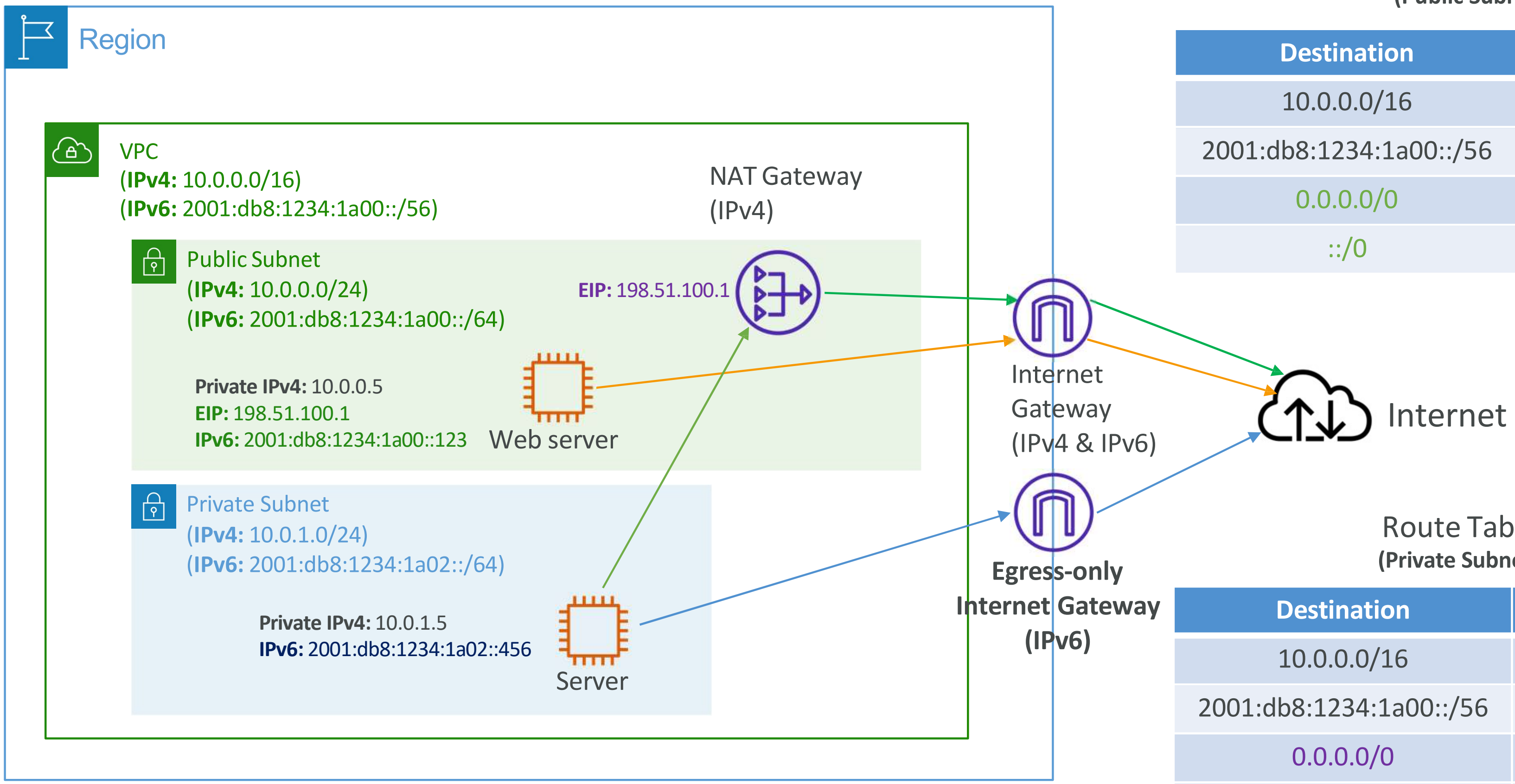
Egress-only Internet Gateway

- Used for IPv6 only
- (similar to a NAT Gateway but for IPv6)

- Allows instances in your VPC outbound connections over IPv6 while preventing the internet to initiate an IPv6 connection to your instances
- You must update the Route Tables


Internet
initiate connections from both sides
can't initiate connections from Internet
VPC
Internet Gateway
Egress-only Internet Gateway
Public Subnet
Private Subnet
IPv6: 2001:db8::b1c2
IPv6: 2001:db8::e1c3

IPv6 Routing



Route Table
(Public Subnet)

Destination	Target
10.0.0.0/16	local
2001:db8:1234:1a00::/56	local
0.0.0.0/0	igw-id
::/0	igw-id

Route Table
(Private Subnet)

Destination	Target
10.0.0.0/16	local
2001:db8:1234:1a00::/56	local
0.0.0.0/0	nat-gateway-id
::/0	eigw-id

VPC Section Summary (1/3)

- CIDR - IP Range
- VPC - Virtual Private Cloud => we define a list of IPv4 & IPv6 CIDR
- Subnets - tied to an AZ, we define a CIDR
- Internet Gateway - at the VPC level, provide IPv4 & IPv6 Internet Access
- Route Tables - must be edited to add routes from subnets to the IGW,VPC Peering Connections,VPC Endpoints, ...
- Bastion Host - public EC2 instance to SSH into, that has SSH connectivity to EC2 instances in private subnets
- NAT Instances - gives Internet access to EC2 instances in private subnets. Old, must be setup in a public subnet, disable Source / Destination check flag
- NAT Gateway - managed by AWS, provides scalable Internet access to private EC2 instances, when the target is an IPv4 address

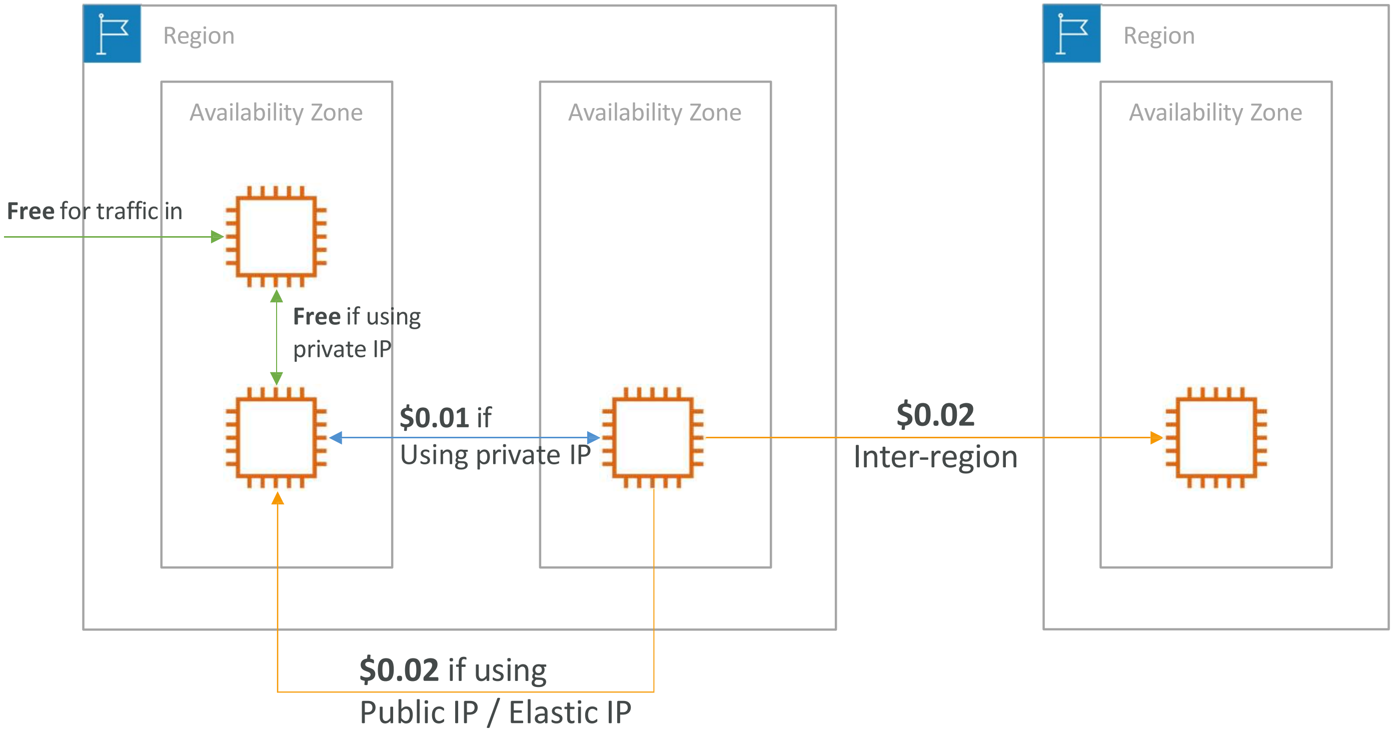
VPC Section Summary (2/3)

- NACL - stateless, subnet rules for inbound and outbound, don't forget Ephemeral Ports
- Security Groups - stateful, operate at the EC2 instance level
- VPC Peering - connect two VPCs with non overlapping CIDR, non-transitive
- VPC Endpoints - provide private access to AWS Services (S3, DynamoDB, CloudFormation, SSM) within a VPC
- VPC Flow Logs - can be setup at the VPC / Subnet / ENI Level, for ACCEPT and REJECT traffic, helps identifying attacks, analyze using Athena or CloudWatch Logs Insights
- Site-to-Site VPN - setup a Customer Gateway on DC, a Virtual Private Gateway on VPC, and site-to-site VPN over public Internet
- AWS VPN CloudHub - hub-and-spoke VPN model to connect your sites

VPC Section Summary (3/3)

- Direct Connect - setup a Virtual Private Gateway on VPC, and establish a direct private connection to an AWS Direct Connect Location
- Direct Connect Gateway - setup a Direct Connect to many VPCs in different AWS regions
- AWS PrivateLink / VPC Endpoint Services:
  - Connect services privately from your service VPC to customers VPC
  - Doesn't need VPC Peering, public Internet, NAT Gateway, Route Tables
  - Must be used with Network Load Balancer & ENI
- ClassicLink - connect EC2-Classic EC2 instances privately to your VPC
- Transit Gateway - transitive peering connections for VPC, VPN & DX
- Traffic Mirroring - copy network traffic from ENIs for further analysis
- Egress-only Internet Gateway - like a NAT Gateway, but for IPv6 targets

Networking Costs in AWS per GB - Simplified

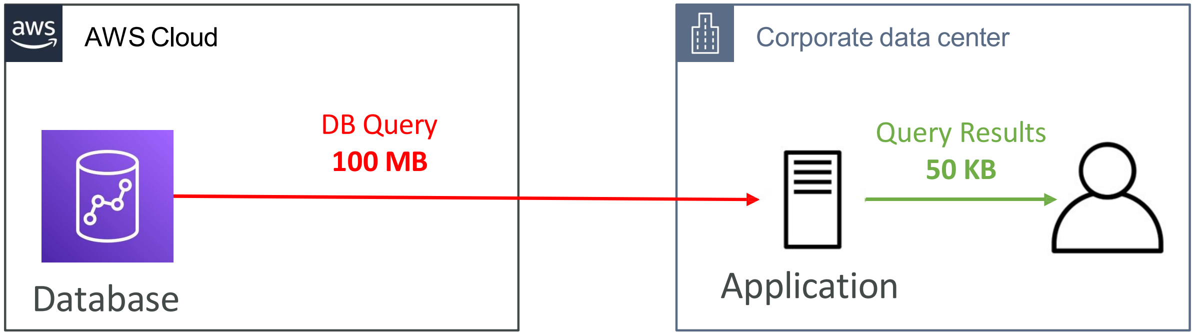


- Use Private IP instead of Public IP for good savings and better network performance
- Use same AZ for maximum savings (at the cost of high availability)

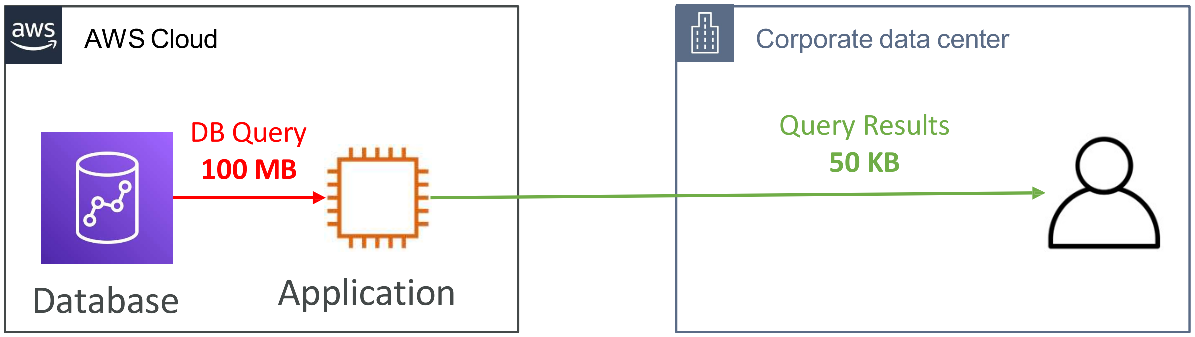
Minimizing egress traffic network cost

- Egress traffic: outbound traffic (from AWS to outside)
- Ingress traffic: inbound traffic - from outside to AWS (typically free)
- Try to keep as much internet traffic within AWS to minimize costs
- Direct Connect location that are co-located in the same AWS Region result in lower cost for egress network

Egress cost is high

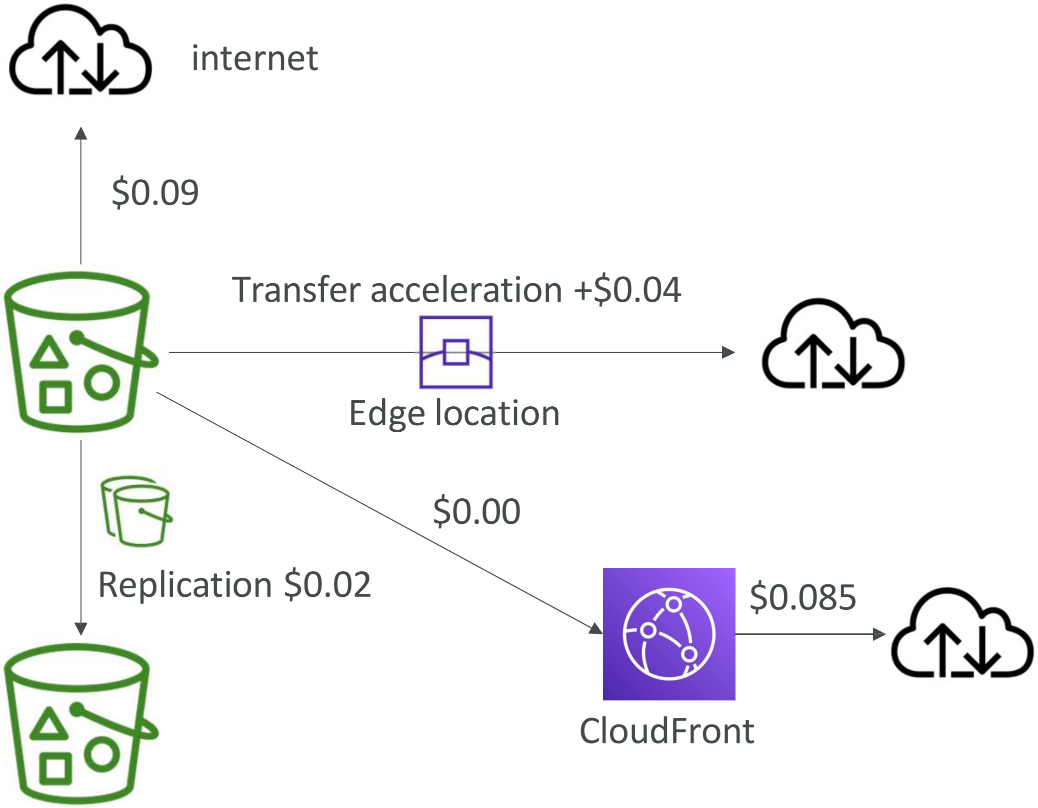


Egress cost is minimized



S3 Data Transfer Pricing – Analysis for USA

- S3 ingress: free
- S3 to Internet: $0.09 per GB
- S3 Transfer Acceleration:
  - Faster transfer times (50 to 500% better)
  - Additional cost on top of Data Transfer Pricing: +$0.04 to $0.08 per GB
- S3 to CloudFront: $0.00 per GB
- CloudFront to Internet: $0.085 per GB (slightly cheaper than S3)
  - Caching capability (lower latency)
  - Reduce costs associated with S3 Requests Pricing (7x cheaper with CloudFront)
- S3 Cross Region Replication: $0.02 per GB



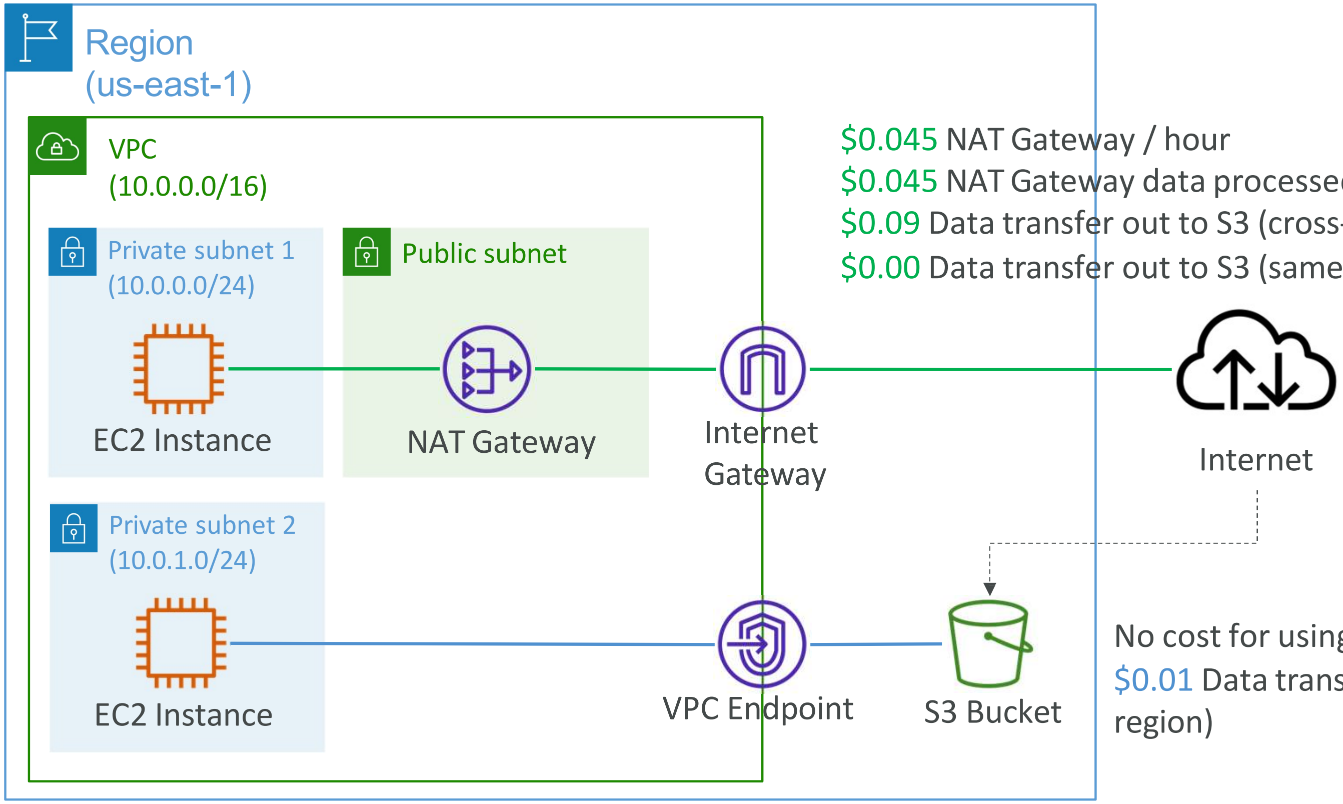
Pricing:
NAT Gateway vs Gateway VPC Endpoint

Subnet 1 route table

Destination	Target
10.0.0.0/16	Local
0.0.0.0/0	igw-id

Subnet 2 route table

Destination	Target
10.0.0.0/16	Local
pl-id for Amazon S3	vpce-id



$0.045 NAT Gateway / hour
$0.045 NAT Gateway data processed / GB
$0.09 Data transfer out to S3 (cross-region)
$0.00 Data transfer out to S3 (same-region)

No cost for using Gateway Endpoint.
$0.01 Data transfer in/out (same-region)

Network Protection on AWS

- To protect network on AWS, we've seen
  - Network Access Control Lists (NACLs)
  - Amazon VPC security groups
  - AWS WAF (protect against malicious requests)
  - AWS Shield & AWS Shield Advanced
  - AWS Firewall Manager (to manage them across accounts)

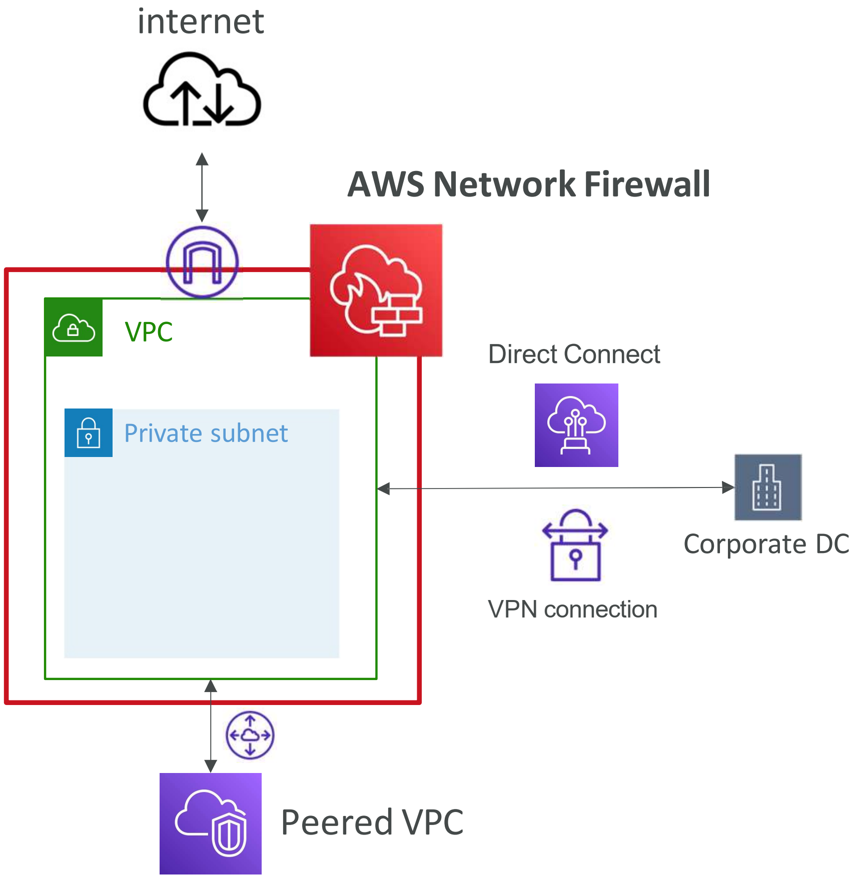
- But what if we want to protect in a sophisticated way our entire VPC?

AWS Network Firewall

- Protect your entire Amazon VPC

- From Layer 3 to Layer 7 protection
- Any direction, you can inspect
    - VPC to VPC traffic
    - Outbound to internet
    - Inbound from internet
    - To / from Direct Connect & Site-to-Site VPN

- Internally, the AWS Network Firewall uses the AWS Gateway Load Balancer
- Rules can be centrally managed cross-account by AWS Firewall Manager to apply to many VPCs



Network Firewall - Fine Grained Controls

- Supports 1000s of rules
  - IP & port - example: 10,000s of IPs filtering
  - Protocol - example: block the SMB protocol for outbound communications
  - Stateful domain list rule groups: only allow outbound traffic to *.mycorp.com or third-party software repo
  - General pattern matching using regex
- Traffic filtering: Allow, drop, or alert for the traffic that matches the rules
- Active flow inspection to protect against network threats with intrusion-prevention capabilities (like Gateway Load Balancer, but all managed by AWS)
- Send logs of rule matches to Amazon S3, CloudWatch Logs, Kinesis Data Firehose