Amazon Web Services – Virtual Private Cloud (VPC)

RICHARD FRISBY
JIMMY MCGIBNEY

Amazon Virtual Private Cloud (VPC)

- An Amazon VPC is an isolated portion of the AWS cloud. You use Amazon VPC to create a virtual network topology for your Amazon EC2 resources.
- You have complete control over your virtual networking environment, including selection of your own IP address range, creation of subnets, and configuration of route tables and network gateways.
- You can create a public-facing subnet for your webservers that has access to the Internet, and place your backend systems such as databases or application servers in a private-facing subnet with no Internet access

Amazon Virtual Private Cloud (VPC)

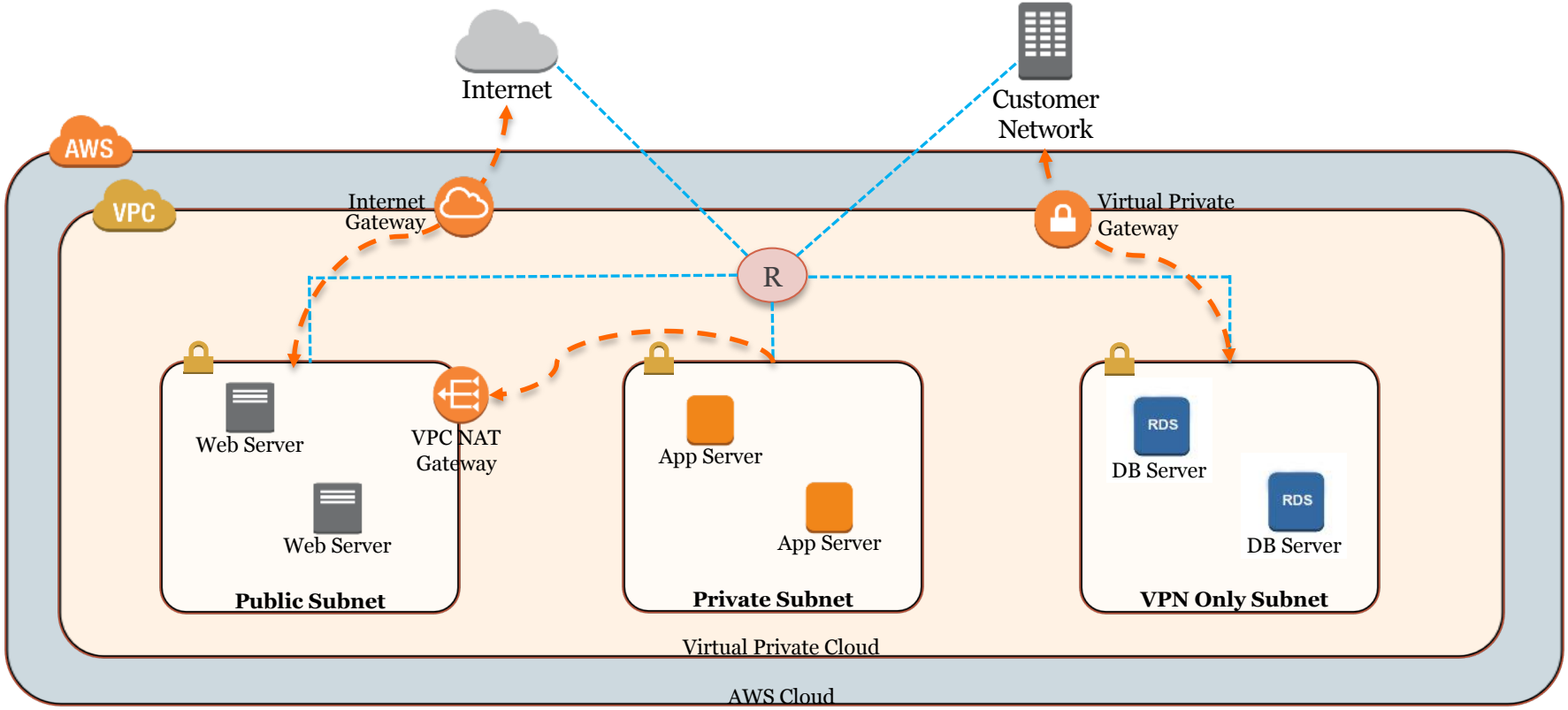
Amazon VPC

- Provision a **private, isolated virtual network** on the AWS cloud.
- Have complete control over your virtual networking environment.

VPCs and subnets

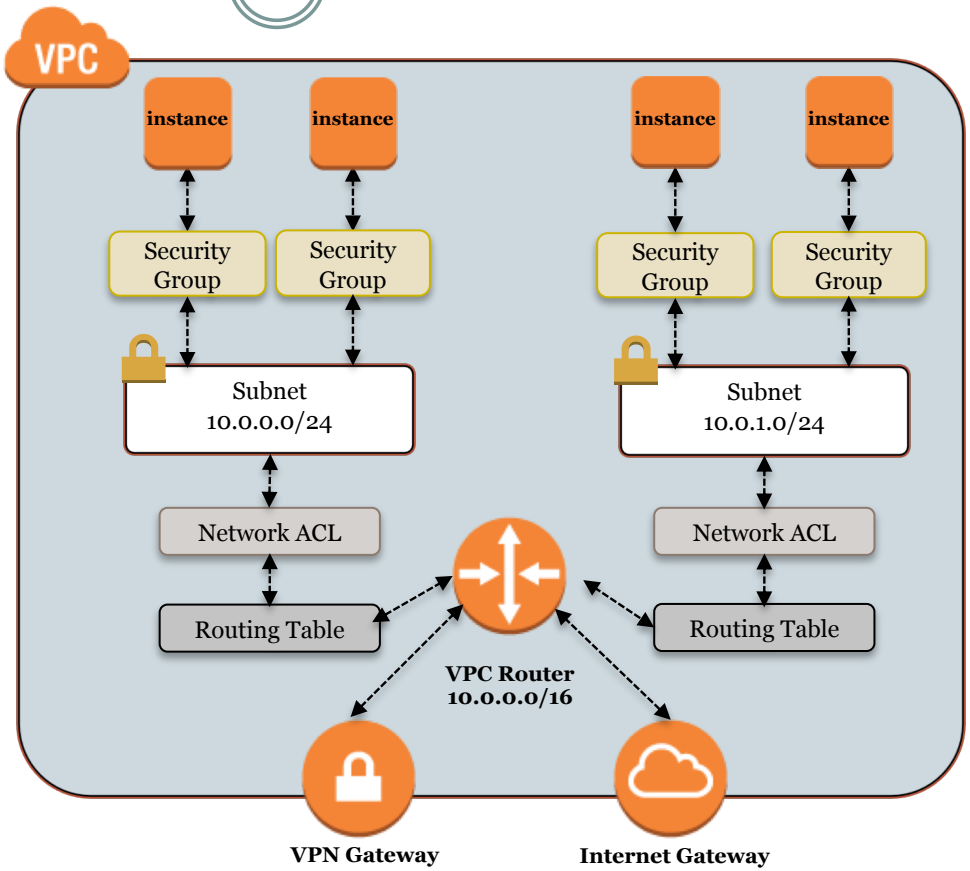
- A **subnet** defines a range of IP addresses in your VPC.
- You can launch AWS resources into a subnet that you select.
- A **private subnet** should be used for resources that won't be accessible over the Internet.
- A **public subnet** should be used for resources that will be accessed over the Internet.
- Each subnet must reside entirely within one Availability Zone and cannot span zones.

VPC example


Internet
Customer Network
AWS
VPC
Internet Gateway
Virtual Private Gateway
R
Web Server
Web Server
VPC NAT Gateway
App Server
App Server
RDS
DB Server
RDS
DB Server
Public Subnet
Private Subnet
VPN Only Subnet
Virtual Private Cloud
AWS Cloud

Security in your VPC

- Security groups
- Network access control lists (ACLs)
- Key Pairs



VPN connections

VPN Connectivity option	Description
AWS Hardware VPN	You can create an **IPsec** hardware VPN connection between your VPC and your remote network.
AWS Direct Connect	AWS Direct Connect provides a **dedicated private** connection from a remote network to your VPC.
AWS VPN CloudHub	You can create multiple **AWS hardware VPN** connections via your VPC to enable communications between various remote networks.
Software VPN	You can create a VPN connection to your remote network by using an Amazon EC2 instance in your VPC that's running a **software VPN appliance**.

Using One VPC

There are **limited** use cases where one VPC could be appropriate:

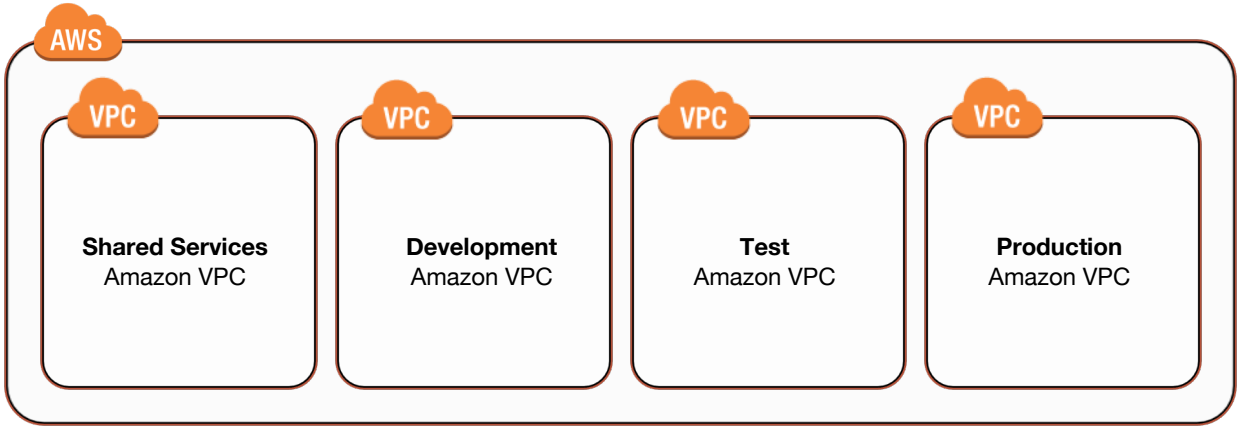
- High-performance computing
- Identity management
- Small, single applications managed by one person or very small team

For **most** use cases, there are two primary patterns for organizing your infrastructure:

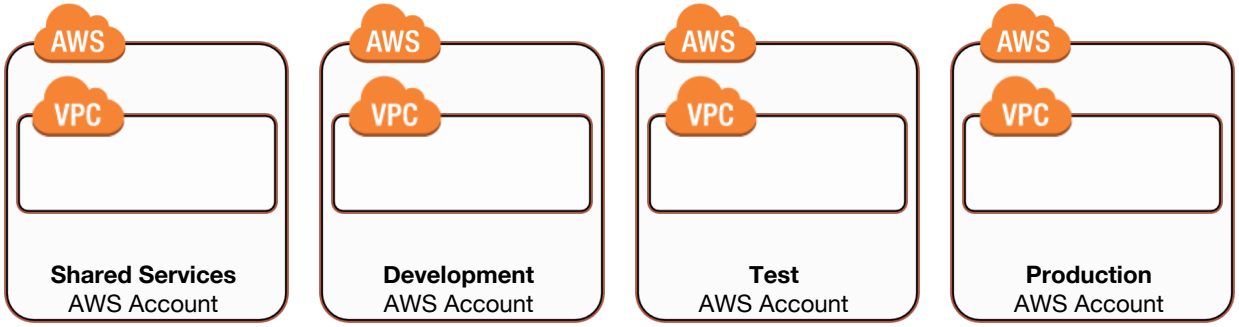
Multi-VPC and **Multi-Account**

AWS Infrastructure Patterns

VPC pattern



Account pattern



Choosing A Pattern

How do you know which pattern to use?

- The primary factors for determining this are the complexity of your organization and your workload isolation requirements:
- Single IT team? Multi-VPC
- Large organization with many IT teams? Multi-account
- High workload isolation required? Multi-account

Other Important Considerations

The majority of AWS services do not actually sit within a VPC.

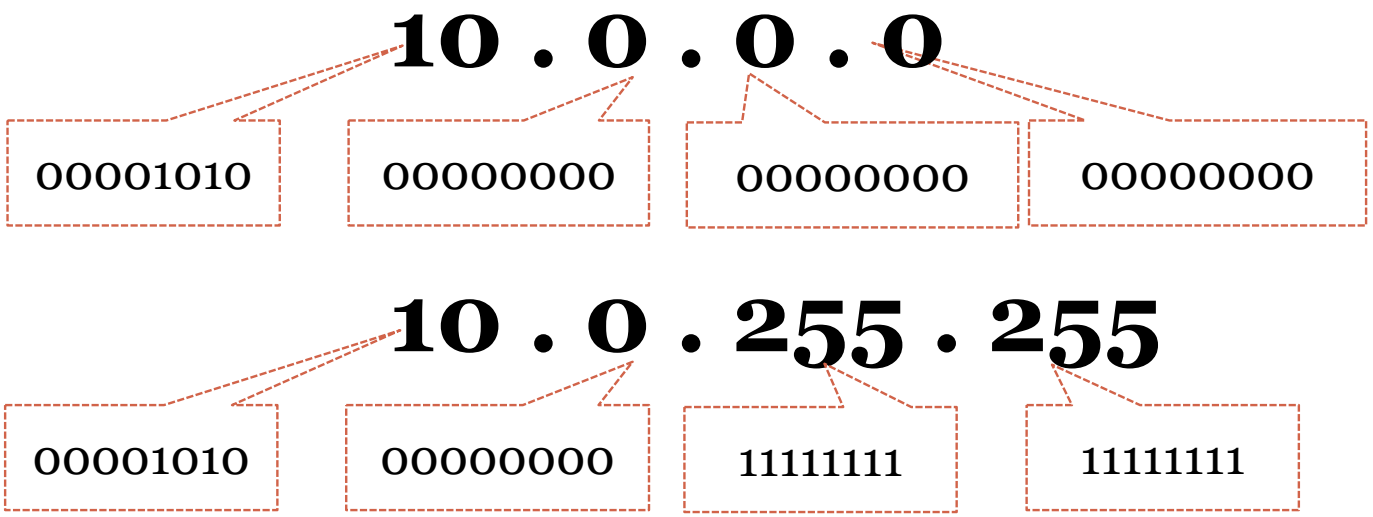
- For these services, a VPC cannot provide any isolation outside of connectivity.
- Network traffic between AWS Regions traverse the AWS global network backbone by default.
- Amazon S3 and DynamoDB offer VPC endpoints to connect without traversing the public Internet.

VPCs And IP Addresses

- When you create your VPC, you specify its set of IP addresses with CIDR notation
- Classless Inter-Domain Routing (CIDR) notation is a simplified way to show a specific range of IP addresses
- Example: 10.0.0.0/16 = all IPs from 10.0.0.0 to 10.0.255.255
- **How does that work?** What does the 16 define?

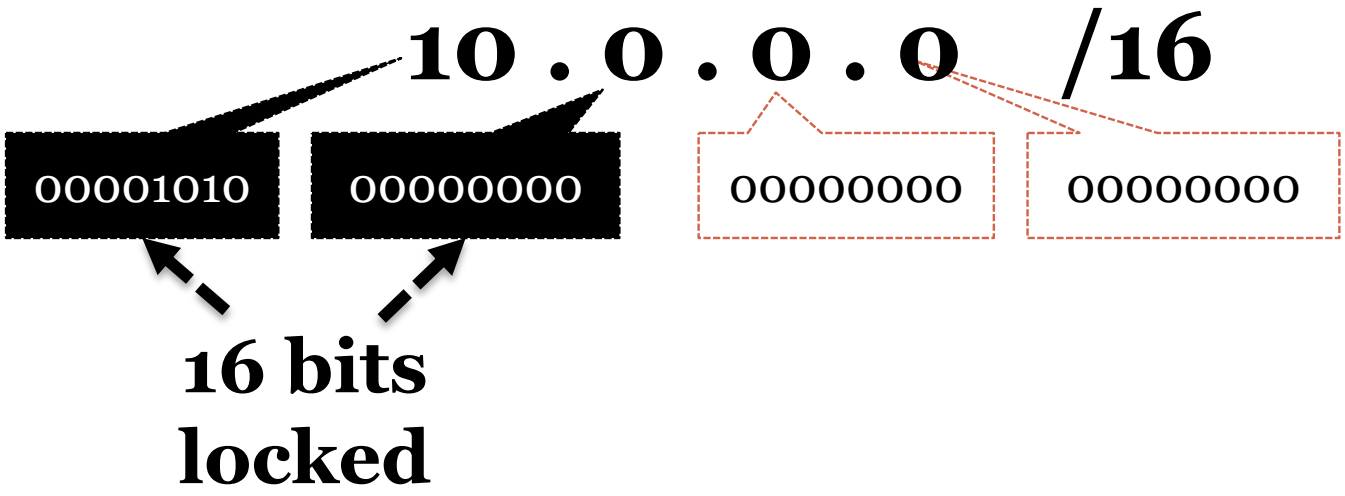
IPs and CIDR

Every set of 4 digits in an IP address represents a set of 8 binary values (8 bits).

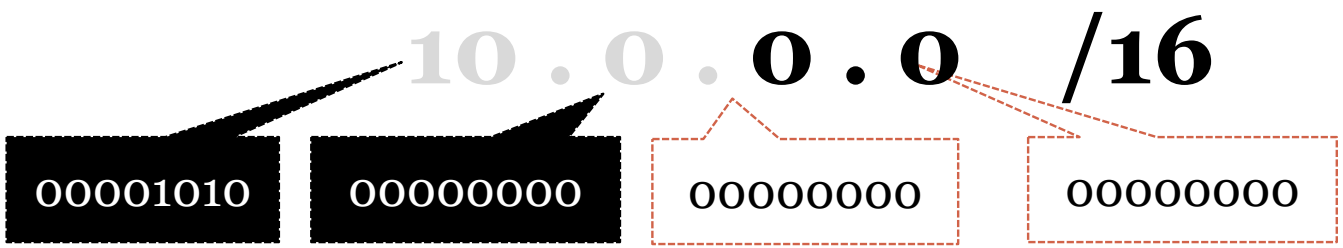


IPs and CIDR

The 16 in the CIDR notation example represents how many of those bits are "locked down" and cannot change.



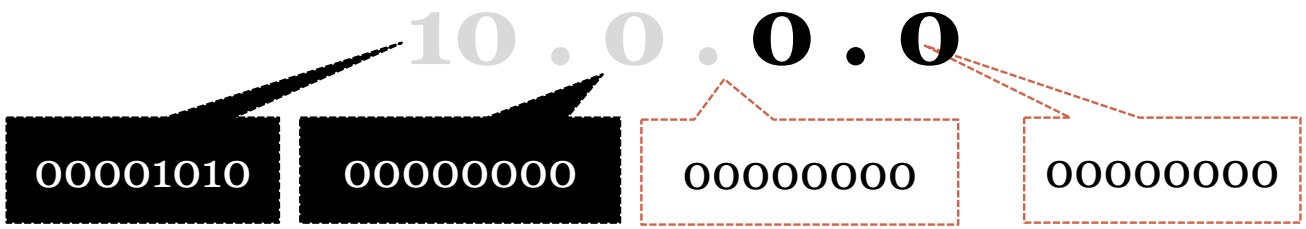
IPs and CIDR



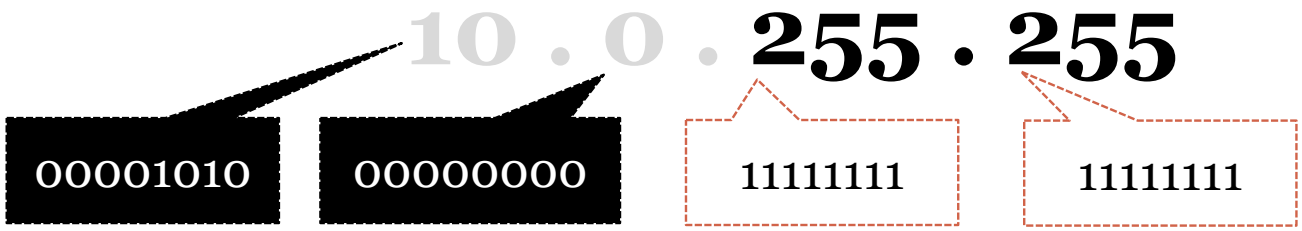
The unlocked bits can change between 1 and 0, allowing the full range of possible values.

CIDR Example: 10.0.0.0/16

Lowest possible IP



Highest possible IP



VPCs and IP Addresses

- AWS VPCs can use CIDR ranges between /16 and /28.
- For every one step a CIDR range increases, the total number of IPs is cut in half:

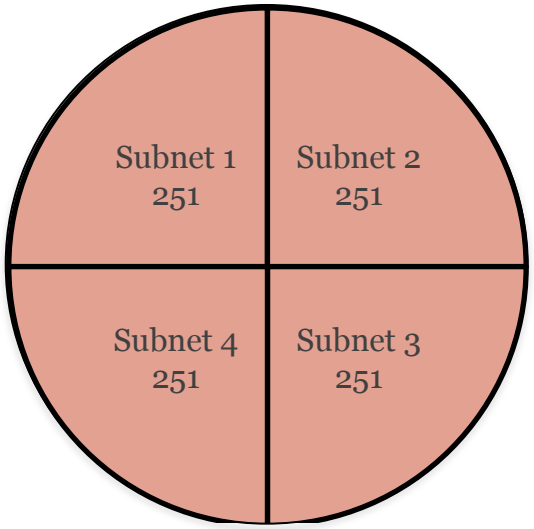
CIDR / Total IPs						
/16	/17	/18	/19	/20	/21	/22
65,536	**32,768**	**16,384**	**8,192**	**4,096**	**2,048**	**1,024**
/23	/24	/25	/26	/27	/28	
512	**256**	**128**	**64**	**32**	**16**	

What Are Subnets?

Subnets are segments or partitions of a network, divided by CIDR range.

Example:

A VPC with CIDR /22 includes 1,024 total IPs



Note: In every subnet, the first four and last one IP addresses are reserved for AWS use.

How to Use Subnets

Recommendation: Use subnets to define Internet accessibility.

Public subnets

Include a routing table entry to an Internet gateway to support inbound/outbound access to the public Internet.

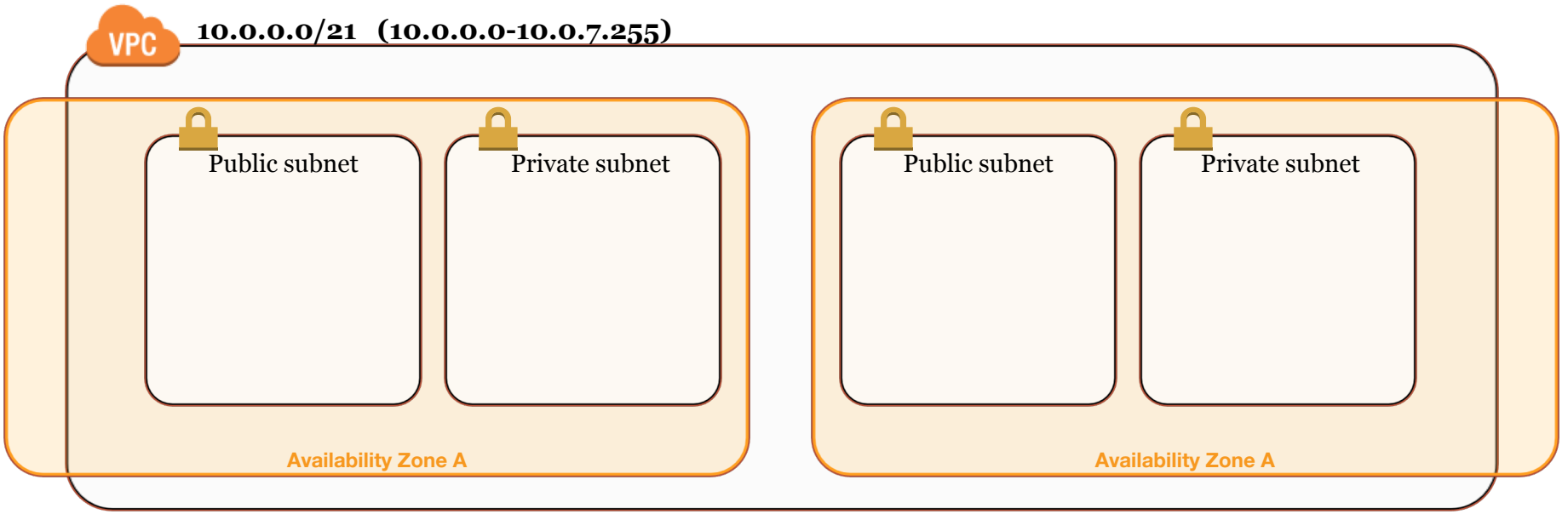
Private subnets

Do not have a routing table entry to an Internet gateway and are not directly accessible from the public Internet.

Typically use a "jump box" (NAT/proxy/bastion host) to support restricted, outbound-only public Internet access.

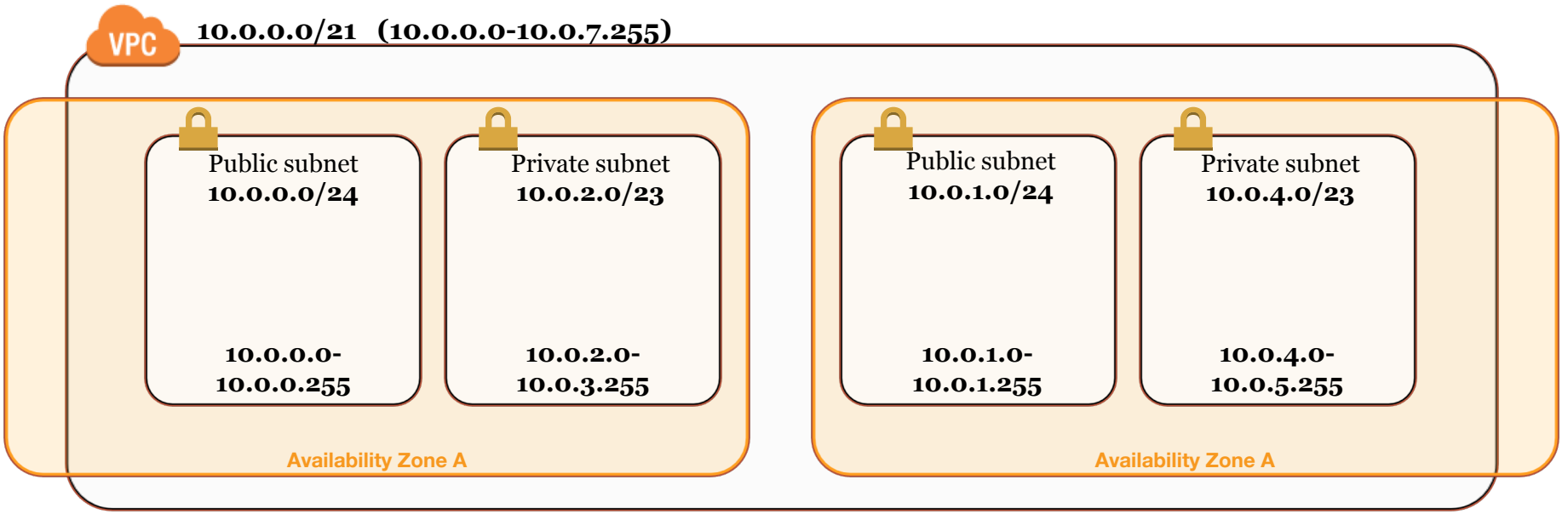
Subnets

Recommendation: Start with one public and one private subnet per Availability Zone.



Subnets

Recommendation: Start with one public and one private subnet per Availability Zone.



Subnet Sizes

Recommendation: Consider larger subnets over smaller ones (/24 and larger).

Simplifies workload placement:

Choosing where to place a workload among 10 small subnets is more complicated than with one large subnet.

Less likely to waste or run out of IPs:

If your subnet runs out of available IPs, you can't add more to that subnet.

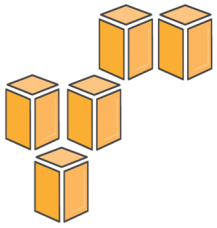
Example: If you have 251 IPs in a subnet that's using only 25 of them, you can't share the unused 226 IPs with another subnet that's running out.

Subnet Types

Which subnet type (public or private) should you use for these resources ?

	Public	Private
Datastore instances	☐	☑
Batch processing instances	☐	☑
Back-end instances	☐	☑
Web application instances	☑	☑

How do you control your VPC traffic?

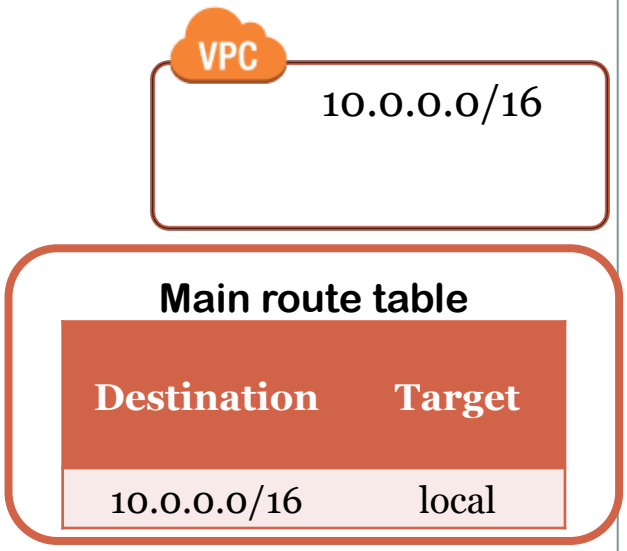


- Route tables
- Security groups
- Network ACLs
- Internet gateways

Route Tables

Directing Traffic Between VPC Resources

- Determine where network traffic is routed
  - Main and custom route tables
  - VPC route table: *Local route*
  - Only one route table per subnet



Best practice:
Use custom route tables for each subnet to enable granular routing for destinations.

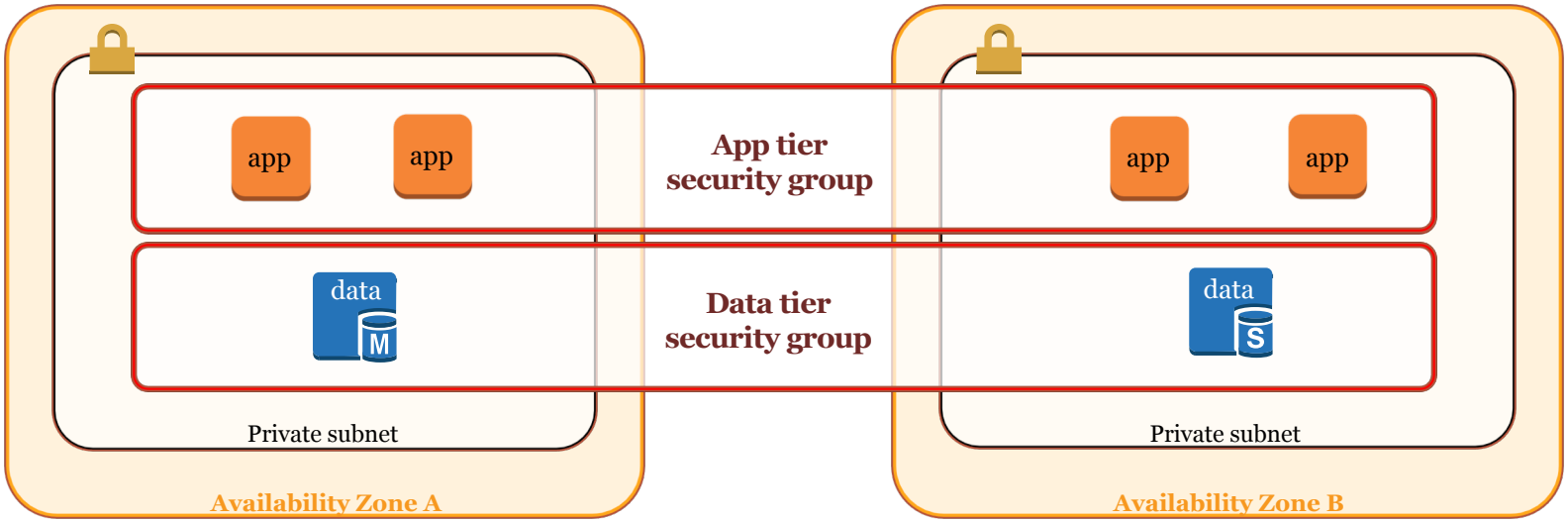
Security Groups

Securing VPC Traffic With Security Groups

- Are virtual firewalls that control inbound and outbound traffic for one or more instances.
- Deny all incoming traffic by default and use *allow* rules that can filter based on TCP, UDP, and ICMP protocols.
- Are *stateful*, which means that if your inbound request is allowed, the outbound response does not have to be inspected/tracked, and vice versa.
- Can define a source/target as either a CIDR block or another security group to handle situations like auto scaling.

Security Groups

Use security groups to control traffic into, out of, and between resources.



How Security Groups Are Configured

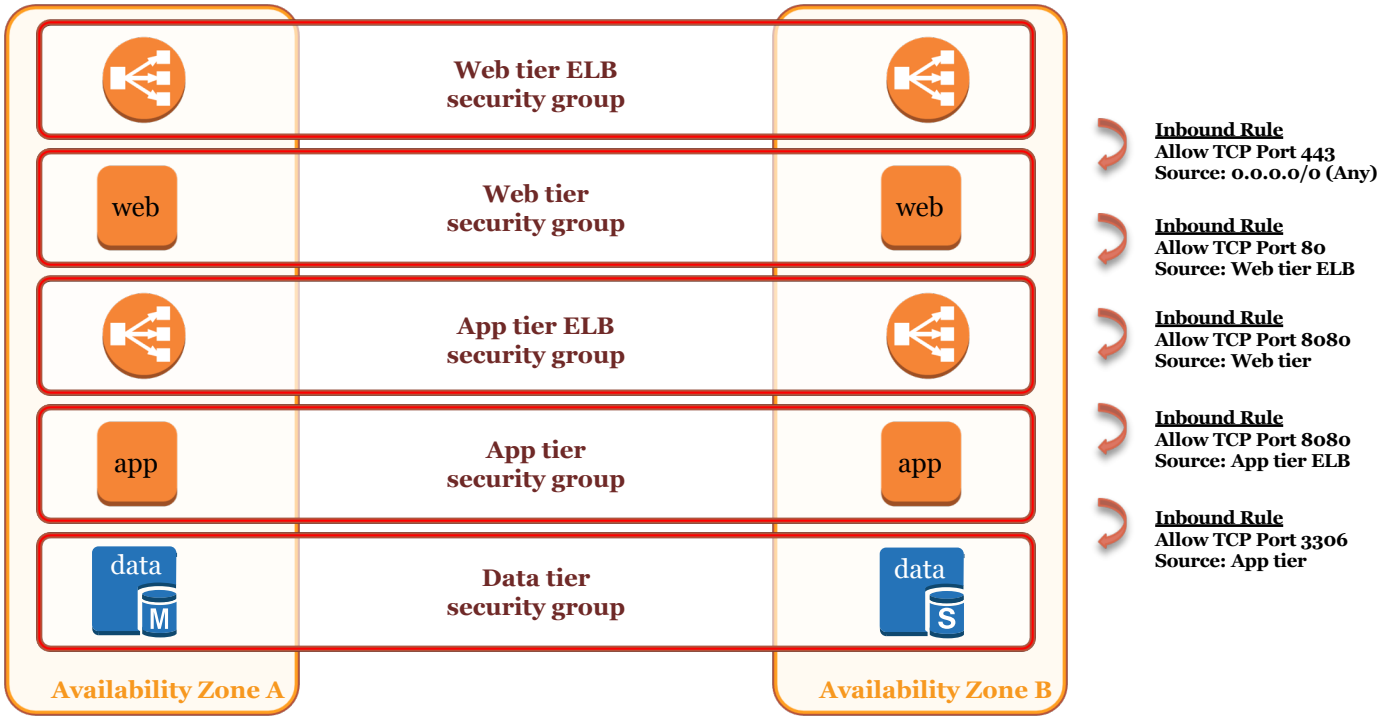
- By default, all newly created security groups **allow all outbound traffic** to all destinations.

  Modifying the default outbound rule on security groups increases complexity and is not recommended unless required for compliance.

- Most organizations create security groups with **inbound rules** for **each functional tier** (web/app/data/etc.) within an application.

Security Group Chaining Diagram

Security group rules per application tier



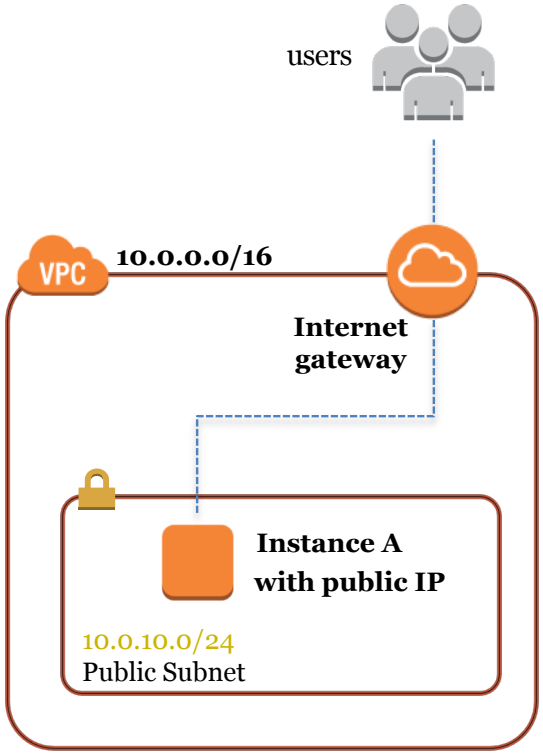
Network ACLs

- Are optional virtual firewalls that control traffic in and out of a subnet.
- Allow all incoming/outgoing traffic by default and use stateless rules to allow or deny traffic.
  "Stateless rules" inspect all inbound and outbound traffic and do not keep track of connections.
- Enforce rules only at the boundary of the subnet, not at the instance-level, like security groups.

Internet gateways

Directing Traffic To Your VPC

- Allow communication between instances in your VPC and the Internet.
- Are horizontally scaled, redundant, and highly available by default.
- Provide a target in your VPC route tables for Internet-routable traffic.



Directing Traffic To Your VPC

To enable access to or from the Internet for instances in a VPC subnet, you must:

- Attach an Internet gateway to your VPC
- Ensure that your subnet's route table points to the Internet gateway
- Ensure that instances in your subnet have public IP addresses or Elastic IP addresses
- Ensure that your NACLs and security groups allow the relevant traffic to flow to and from your instance

What About Outbound Traffic From Private Instances?

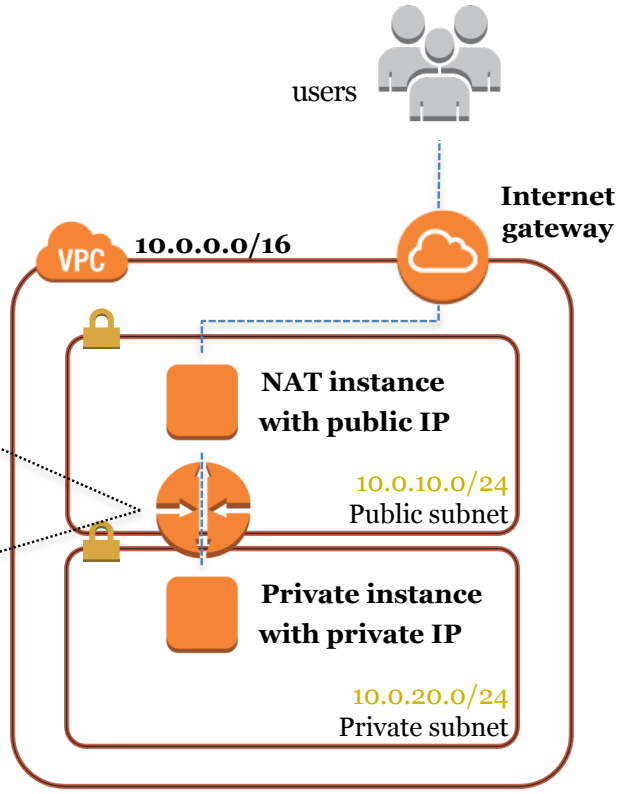
Network Address Translation services:

- Enable instances in the private subnet to initiate outbound traffic to the Internet or other AWS services.
- Prevent private instances from receiving inbound traffic from the Internet.

Two primary options:

- Amazon EC2 instance set up as a NAT in a public subnet
- VPC NAT Gateway

Destination	Target
10.0.0.0/16	local
0.0.0.0/0	NAT



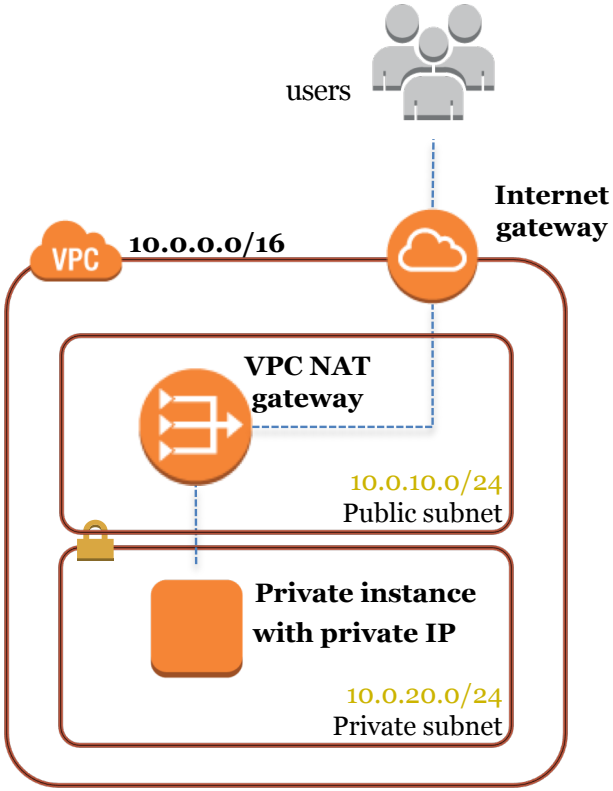
What About Outbound Traffic From Private Instances ?

Network Address Translation services:

- Enable instances in the private subnet to initiate outbound traffic to the Internet or other AWS services.
- Prevent private instances from receiving inbound traffic from the Internet.

Two primary options:

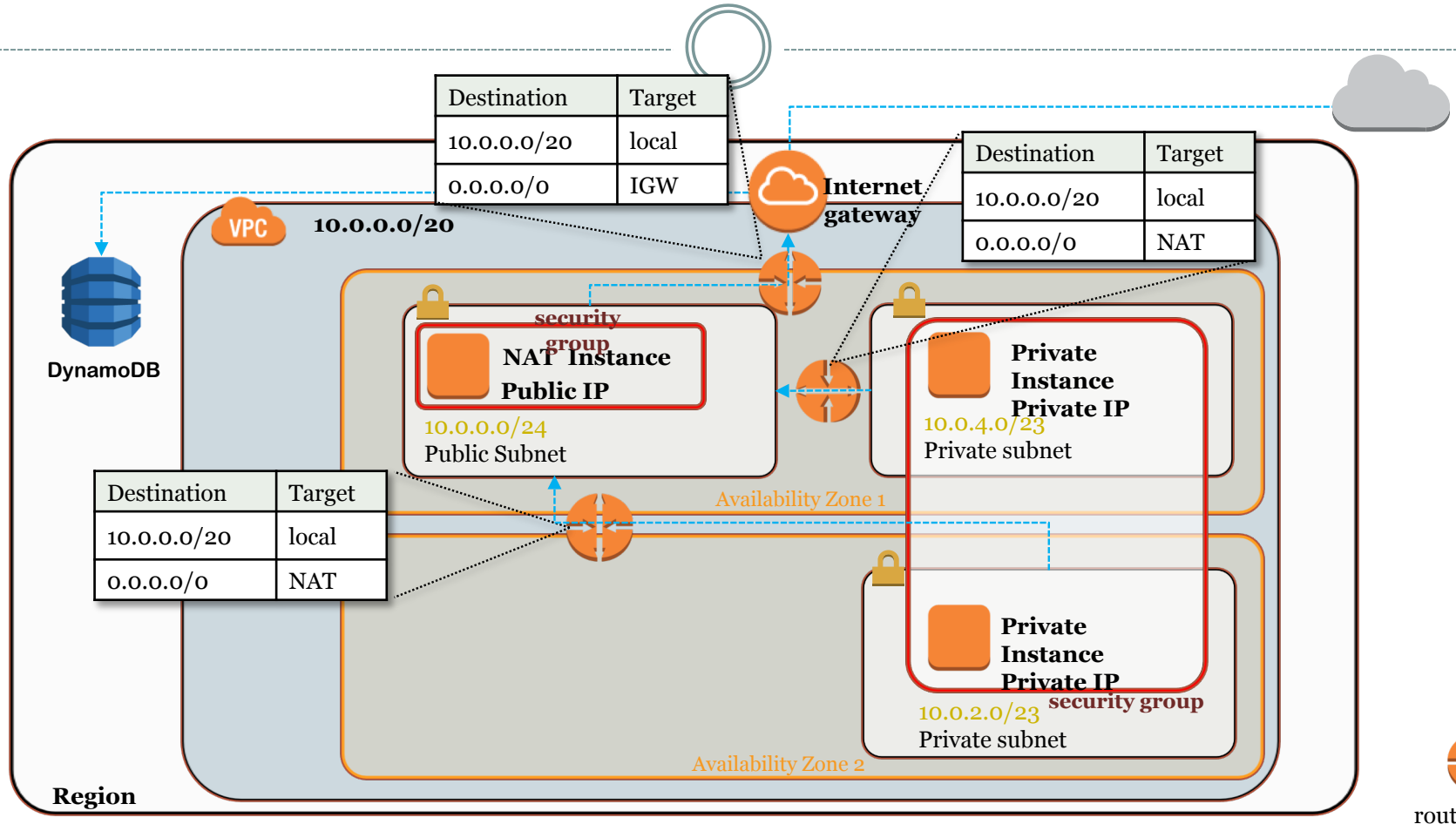
- Amazon EC2 instance set up as a NAT in a public subnet
- VPC NAT Gateway



VPC NAT Gateways vs. NAT Instances On Amazon EC2

	VPC NAT gateway	NAT instance
Availability	Highly available by default	Use script to manage failover
Bandwidth	Bursts to 10 Gbps	Based on bandwidth of instance type
Maintenance	Managed by AWS	Managed by you
Security	NACLs	Security groups and NACLs
Port forwarding	Not supported	Supported

Subnets, Gateways, and Routes



Logging VPC Traffic

Amazon VPC Flow Logs

- Captures traffic flow details in your VPC
  Accepted and rejected traffic
- Can be enabled for VPCs, subnets, and ENIs
- Logs published to CloudWatch Logs

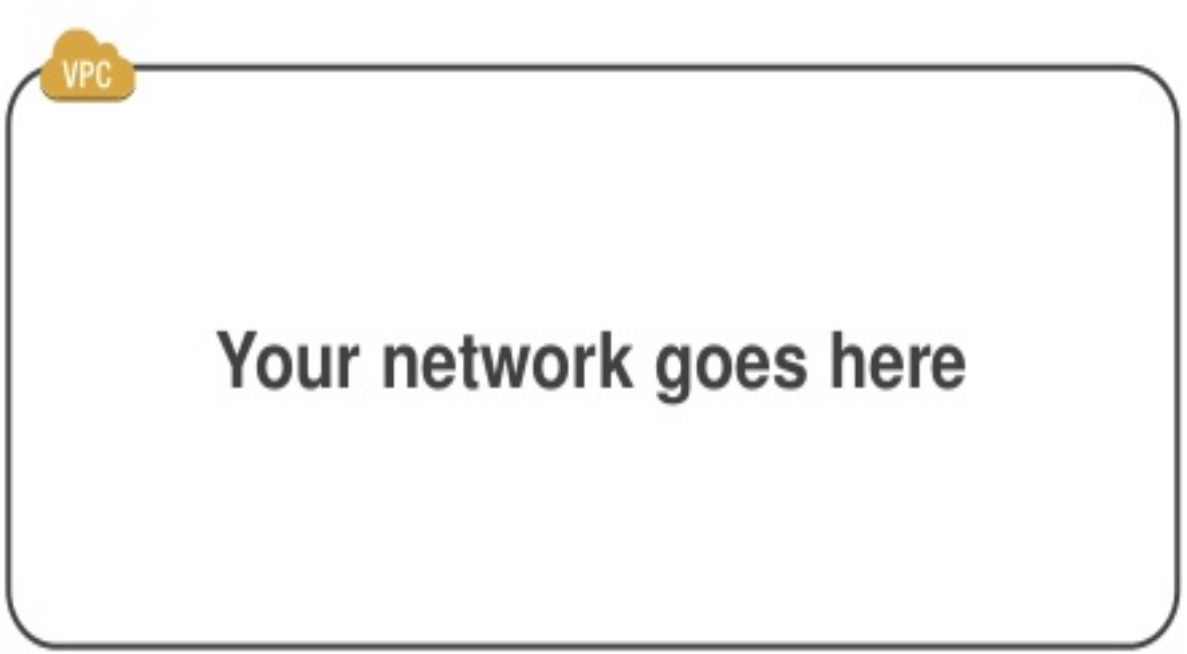
Use cases:

- Troubleshoot connectivity issues.
- Test network access rules.
- Monitor traffic.
- Detect and investigate security incidents.

Amazon Virtual Private Cloud (VPC)

VPC Overview

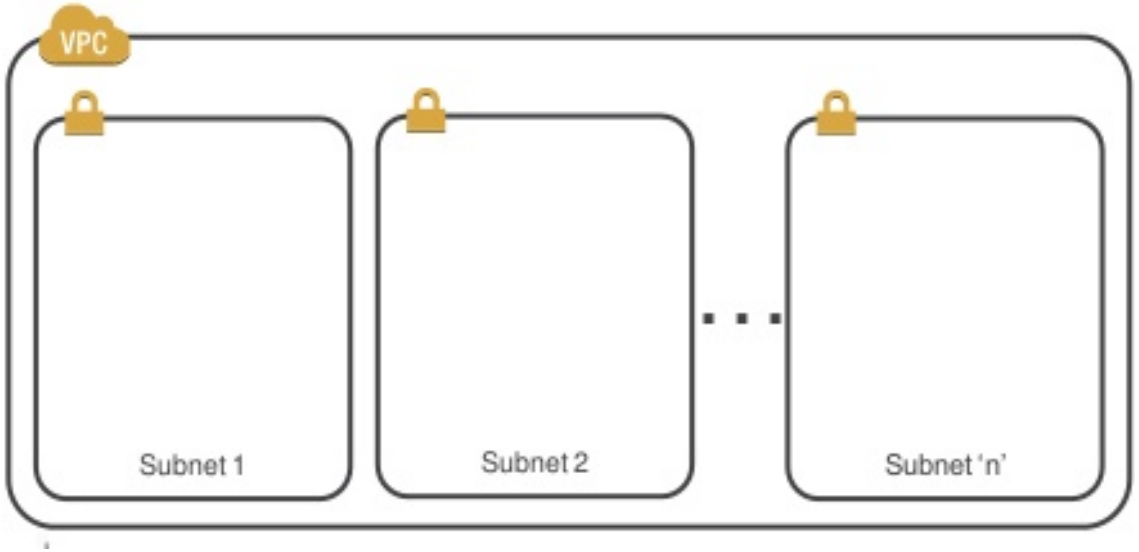
- Bring your own network



Amazon Virtual Private Cloud (VPC)

VPC Overview

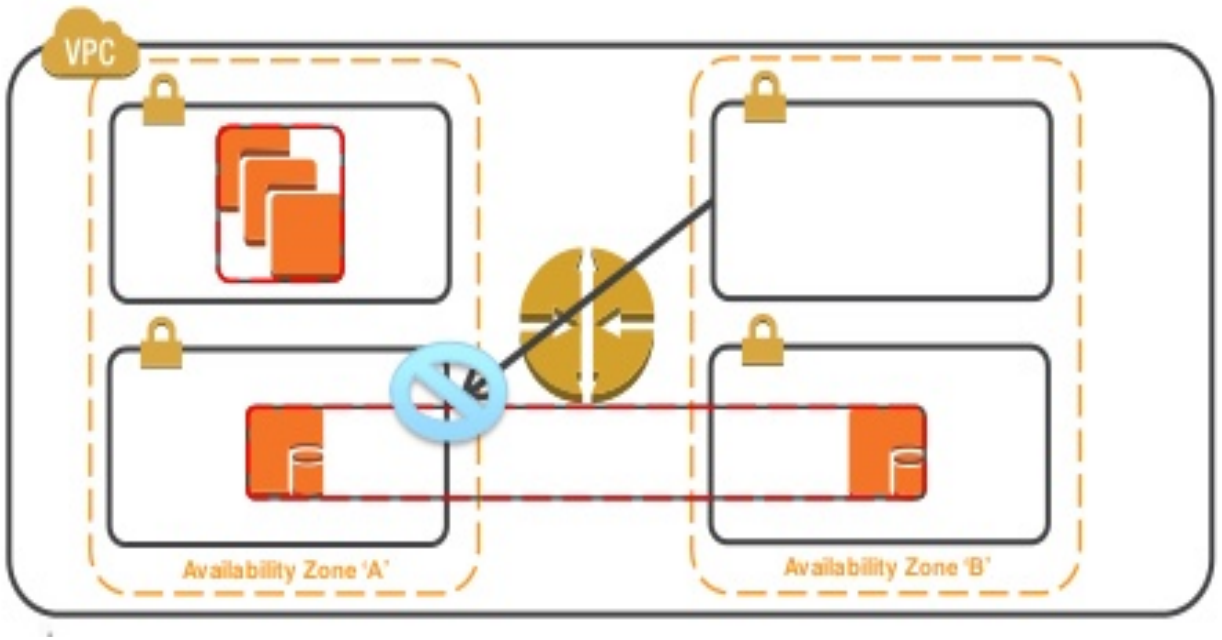
- Bring your own network
- Create your own subnets



Amazon Virtual Private Cloud (VPC)

VPC Overview

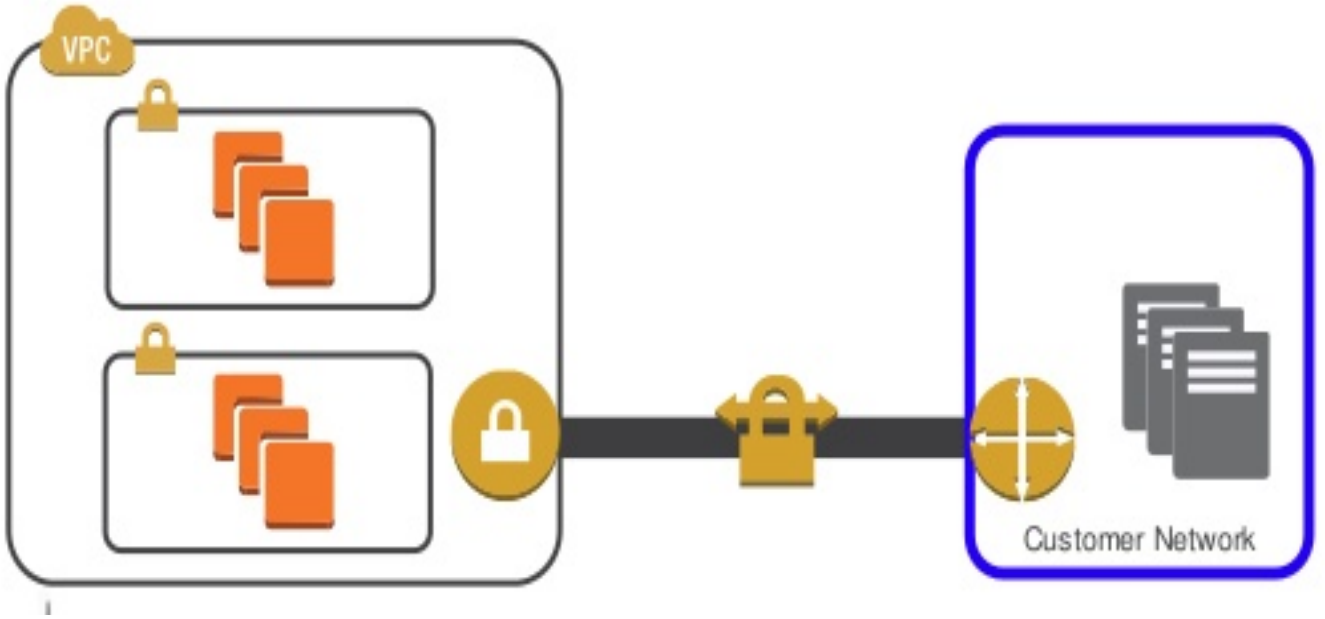
- Control instance placement and traffic
  - Security Groups & NACLs



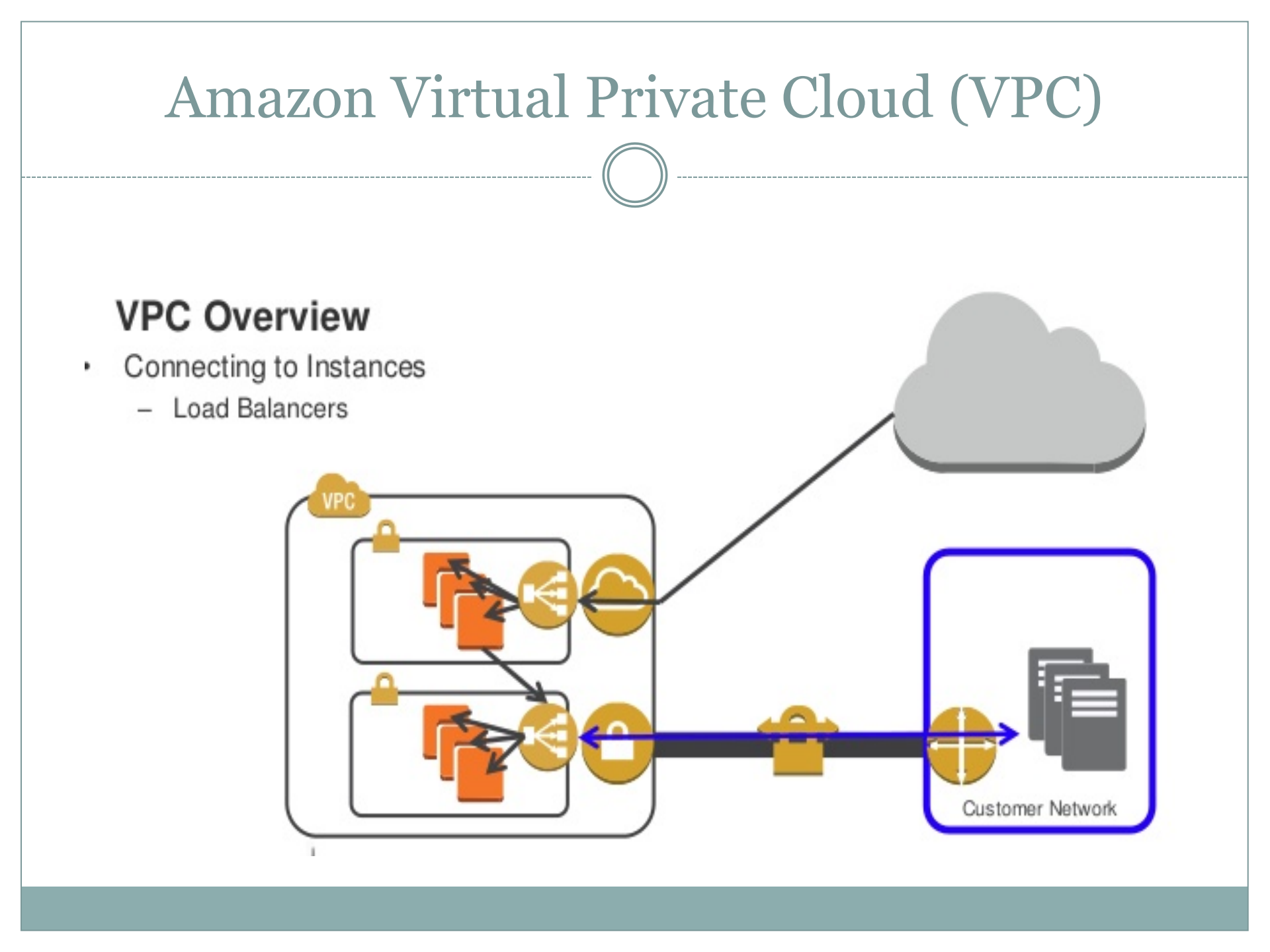
Amazon Virtual Private Cloud (VPC)

VPC Overview

- Virtual Private Gateway
  - IPSEC VPN



Amazon Virtual Private Cloud (VPC)

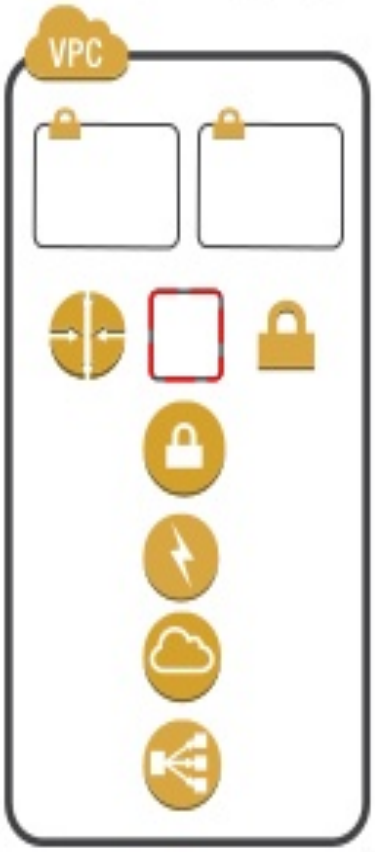


VPC Overview

- Connecting to Instances
  - Load Balancers

Amazon Virtual Private Cloud (VPC)

VPC Building Blocks Summary



Virtual Private Cloud

Subnets

Route Tables, Security Groups, NACLs

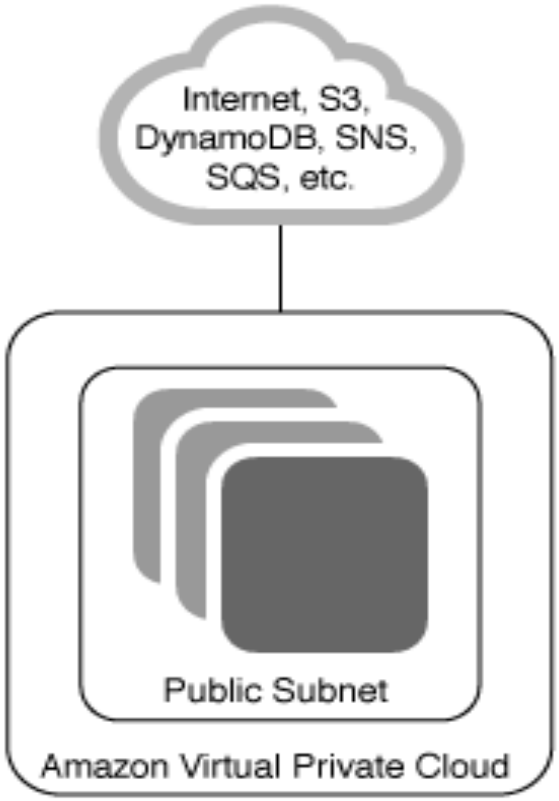
Virtual Private Gateway

AWS Direct Connect

Internet Gateway

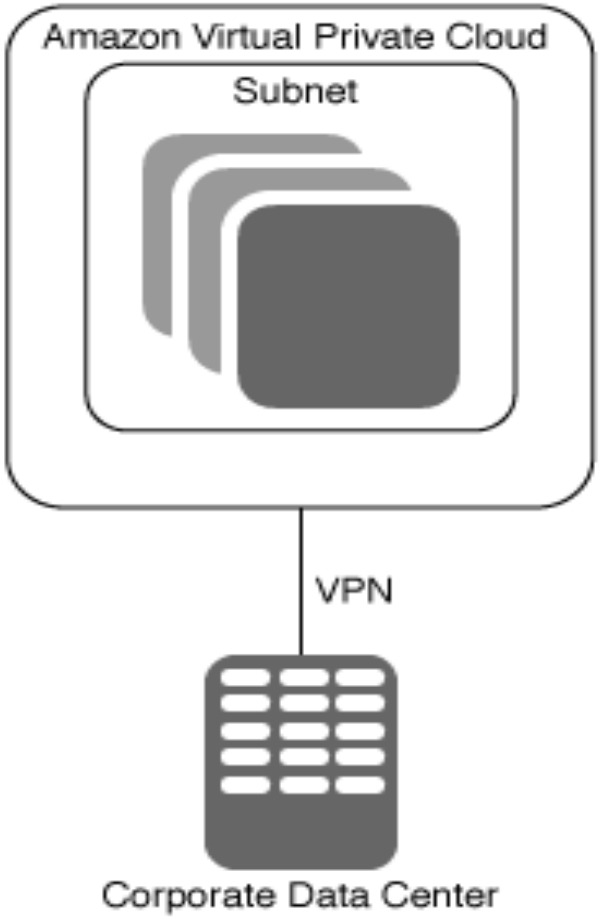
Elastic IPs and Load Balancers

AWS VPC (Single Public Subnet)



Your instances run in a private, isolated section of the AWS cloud with direct access to the Internet. Network access control lists and security groups can be used to provide strict control over inbound and outbound network traffic to your instances.

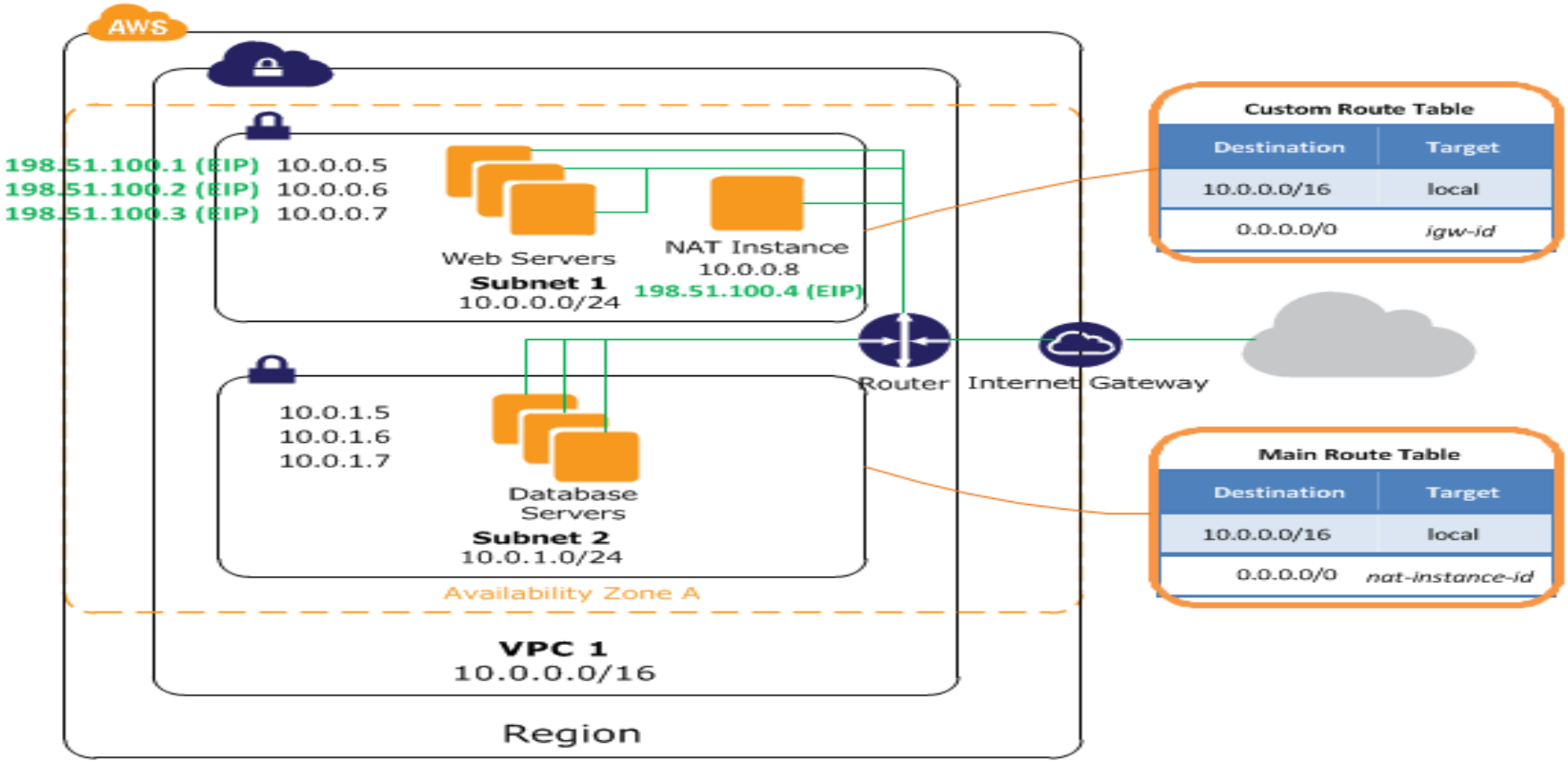
AWS VPC (Single Private Subnet H/W VPN)



Your instances run in a private, isolated section of the AWS cloud with a private subnet whose instances are not addressable from the Internet. You can connect this private subnet to your corporate data center via an IPsec Virtual Private Network (VPN) tunnel.

AWS VPC

- This is a diagram of a typical scenario you can create full details can be found here.



AWS VPC

VPC Dashboard

Filter by VPC:

None

Virtual Private Cloud

Your VPCs

Resources

Start VPC Wizard | Launch EC2 Instances

Note: Your Instances will launch in the EU West (Ireland) region.

You are using the following Amazon VPC resources in the EU West (Ireland) region:

Step 1: Select a VPC Configuration

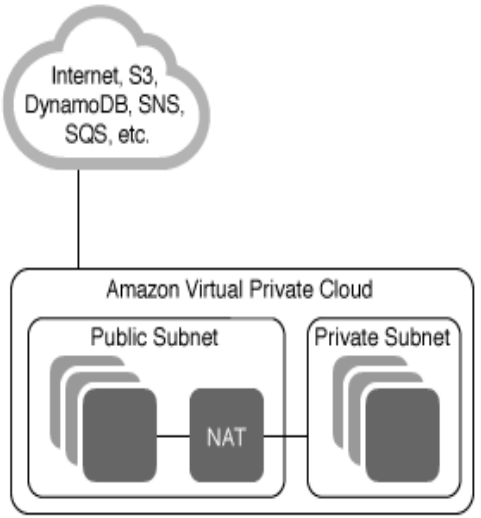
- VPC with a Single Public Subnet
- **VPC with Public and Private Subnets**
- VPC with Public and Private Subnets and Hardware VPN Access
- VPC with a Private Subnet Only and Hardware VPN Access

In addition to containing a public subnet, this configuration adds a private subnet whose instances are not addressable from the Internet. Instances in the private subnet can establish outbound connections to the Internet via the public subnet using Network Address Translation (NAT).

Creates:

A /16 network with two /24 subnets. Public subnet instances use Elastic IPs to access the Internet. Private subnet instances access the Internet via a Network Address Translation (NAT) instance in the public subnet. (Hourly charges for NAT instances apply.)

Select



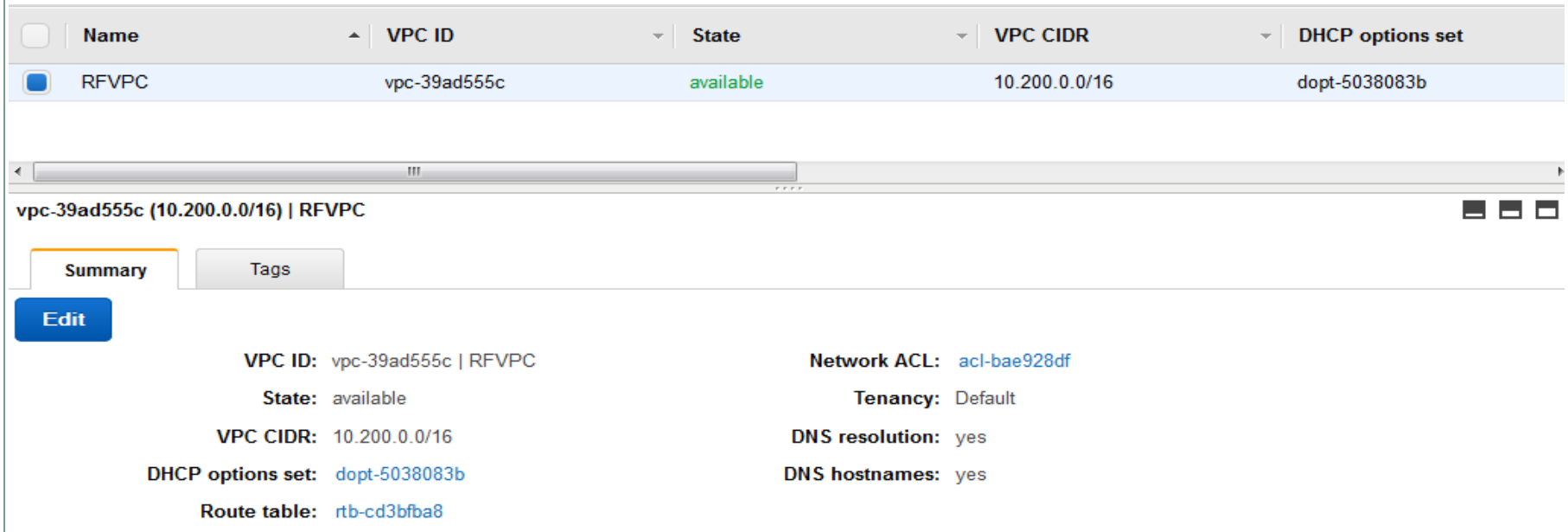
AWS VPC

You will need to create the following security groups

- WebServerSG—For the web servers in the public subnet
- DBServerSG—For the database servers in the private subnet

AWS VPC

- From the Your VPCs screen note the details for your VPC – VPC ID, DHCP Options set, Main Route table, Default Network ACL.
- Also note the Subnets, Internet Gateways and Elastic IPs that have been created for your VPC. Your should clearly name your VPC resources.



AWS VPC

- You can choose yourself whether you want to work with Windows or Linux machines or a mixture of both.
- Launch a web server in the Public subnet in the VPC. Make sure you enable Auto-Assign Public IP address.
- You should put in some meaningful details in the Instance details tags key – value screen e.g. RFwebserver
- Launch the server in the relevant Security Group e.g. RFWebServerSG
- You will see both the Private and Public IP addresses assigned to this server. You can configure a webserver and connect to the Public IP address from your own desktop.

AWS VPC

- Now you can launch a Linux instance – you can choose a basic AMI - this instance must be launched in the private. This Server should be launched into the DBServerSG.
- You **DO NOT** want to Auto-Assign a Public IP address to this server.
- If you enable ssh from the WebServerSG to the DBServerSG you will be able to login from the Server in the Public subnet to the server in the Private subnet.
- Once you ssh from your webserver instance to your dbinstance you can check your public IP address using **wget http://ipinfo.io/ip -qO –**
- What is the Public IP address of the server in your Private Network ? What does it correspond with?

AWS VPC

- When you have investigated this VPC Scenario you can terminate your instances in the Public and Private subnets.
- In this exercise you created your own VPC with Public and Private subnets.
- Note you can delete your VPC and all associated resources (NAT gateway, instances, Elastic IPs, etc.)

References

- http://docs.aws.amazon.com/AmazonVPC/latest/UserGuide/VPC_Scenario2.html
- How to securely manage AWS credentials
  - https://blogs.aws.amazon.com/security/post/Tx3D6U6WSFGOK2H/A-New-and-Standardized-Way-to-Manage-Credentials-in-the-AWS-SDKs
- How to login securely to Linux AMI in VPC Private subnet using ssh agent forwarding
  - https://blogs.aws.amazon.com/security/post/Tx3N8GFK85UN1G6/Securely-connect-to-Linux-instances-running-in-a-private-Amazon-VPC