

High Availability & Scalability

Scalability & High Availability

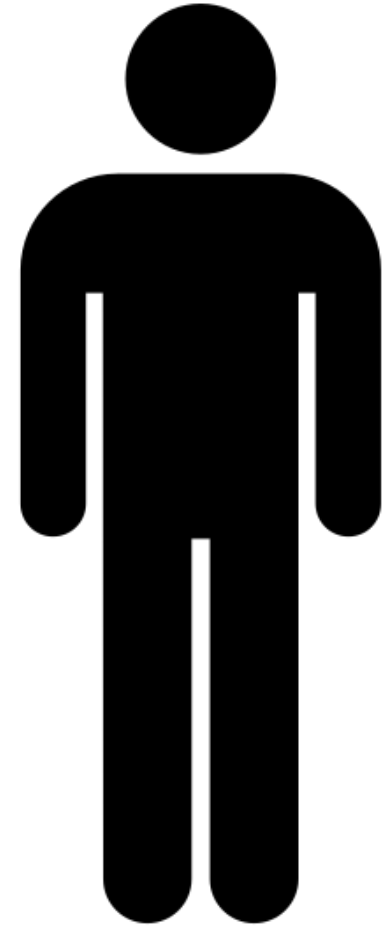
- Scalability means that an application / system can handle greater loads by adapting.
- There are two kinds of scalability:
 - Vertical Scalability
 - Horizontal Scalability (= elasticity)
- Scalability is linked but different to High Availability
- Let's deep dive into the distinction, using a call center as an example

Vertical Scalability

- Vertically scalability means increasing the size of the instance
- For example, your application runs on a t2.micro
- Scaling that application vertically means running it on a t2.large
- Vertical scalability is very common for non distributed systems, such as a database.
- RDS, ElastiCache are services that can scale vertically.
- There's usually a limit to how much you can vertically scale (hardware limit)



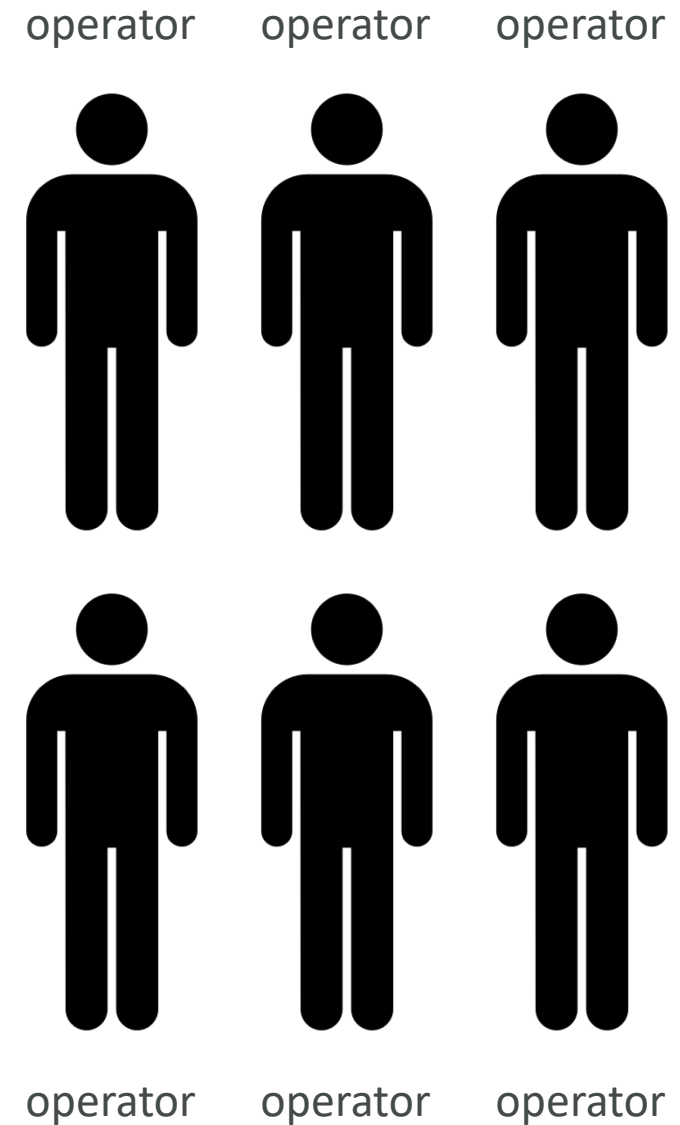
junior operator



senior operator

Horizontal Scalability

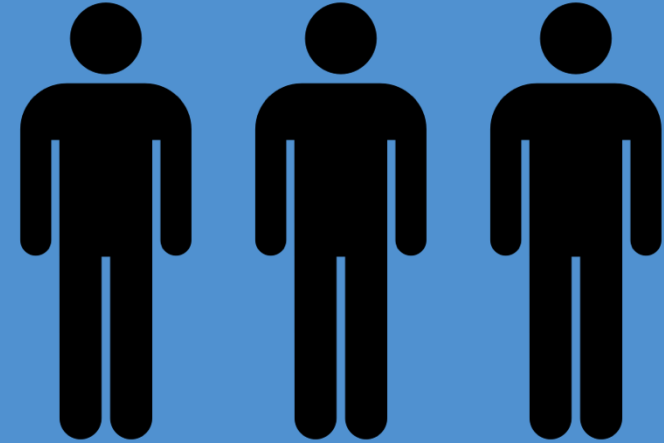
- Horizontal Scalability means increasing the number of instances / systems for your application
- Horizontal scaling implies distributed systems.
- This is very common for web applications / modern applications
- It's easy to horizontally scale thanks the cloud offerings such as Amazon EC2



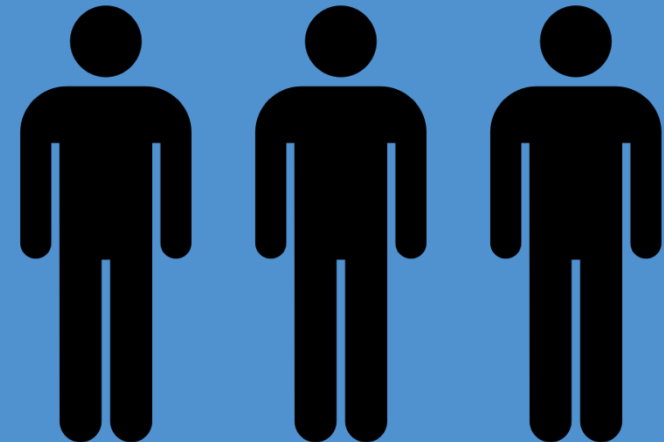
High Availability

- High Availability usually goes hand in hand with horizontal scaling
- High availability means running your application / system in at least 2 data centers (== Availability Zones)
- The goal of high availability is to survive a data center loss
- The high availability can be passive (for RDS Multi AZ for example)
- The high availability can be active (for horizontal scaling)

first building in New York



second building in San Francisco

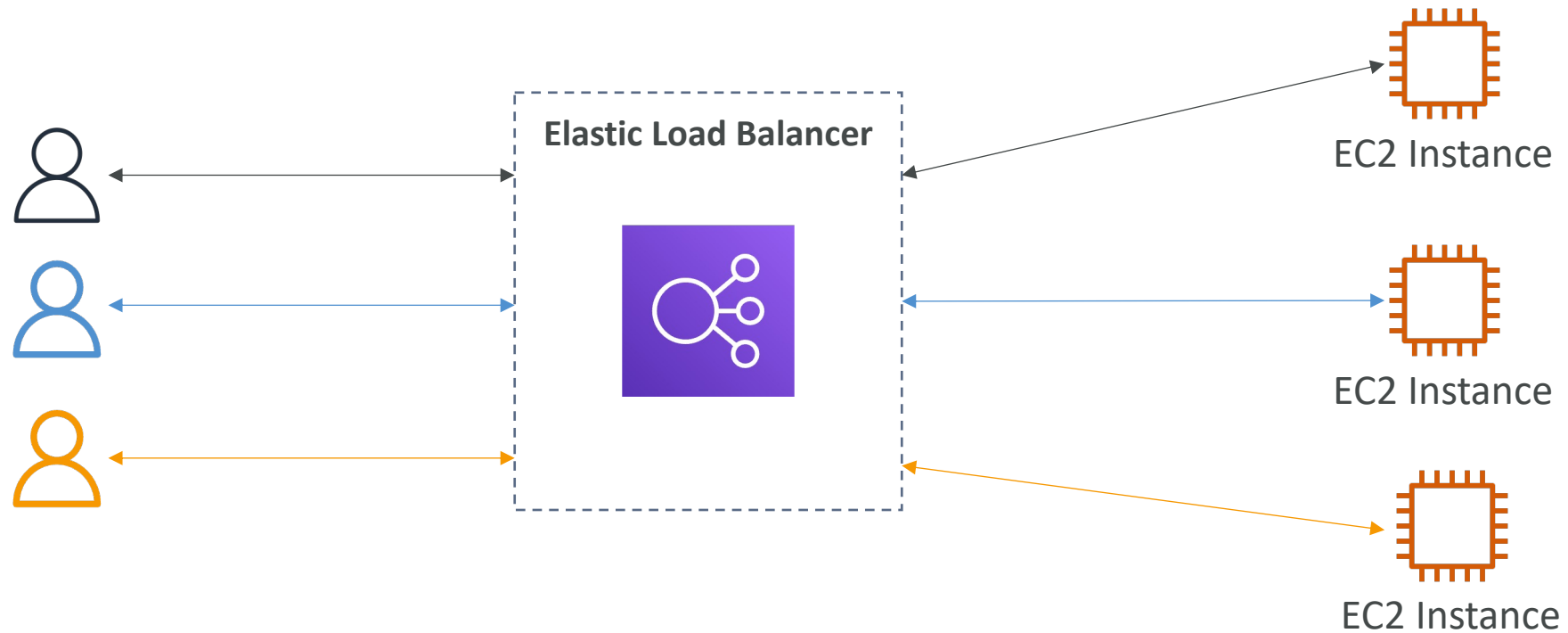


High Availability & Scalability For EC2

- Vertical Scaling: Increase instance size (= scale up / down)
 - From: t2.nano - 0.5G of RAM, 1 vCPU
 - To: u-12tb1.metal – 12.3 TB of RAM, 448 vCPUs
- Horizontal Scaling: Increase number of instances (= scale out / in)
 - Auto Scaling Group
 - Load Balancer
- High Availability: Run instances for the same application across multi AZ
 - Auto Scaling Group multi AZ
 - Load Balancer multi AZ

What is load balancing?

- Load Balancers are servers that forward traffic to multiple servers (e.g., EC2 instances) downstream



Why use a load balancer?

- Spread load across multiple downstream instances
- Expose a single point of access (DNS) to your application
- Seamlessly handle failures of downstream instances
- Do regular health checks to your instances
- Provide SSL termination (HTTPS) for your websites
- Enforce stickiness with cookies
- High availability across zones
- Separate public traffic from private traffic

Why use an Elastic Load Balancer?

- An Elastic Load Balancer is a **managed load balancer**
 - AWS guarantees that it will be working
 - AWS takes care of upgrades, maintenance, high availability
 - AWS provides only a few configuration knobs
- It costs less to setup your own load balancer but it will be a lot more effort on your end
- It is integrated with many AWS offerings / services
 - EC2, EC2 Auto Scaling Groups, Amazon ECS
 - AWS Certificate Manager (ACM), CloudWatch
 - Route 53, AWS WAF, AWS Global Accelerator

Health Checks

- Health Checks are crucial for Load Balancers
- They enable the load balancer to know if instances it forwards traffic to are available to reply to requests
- The health check is done on a port and a route (/health is common)
- If the response is not 200 (OK), then the instance is unhealthy





Types of load balancer on AWS

- AWS has **4 kinds of managed Load Balancers**
- **Classic Load Balancer** (v1 - old generation) – 2009 – CLB
 - HTTP, HTTPS, TCP, SSL (secure TCP)
- **Application Load Balancer** (v2 - new generation) – 2016 – ALB
 - HTTP, HTTPS, WebSocket
- **Network Load Balancer** (v2 - new generation) – 2017 – NLB
 - TCP, TLS (secure TCP), UDP
- **Gateway Load Balancer** – 2020 – GWLB
 - Operates at layer 3 (Network layer) – IP Protocol
- Overall, it is recommended to use the newer generation load balancers as they provide more features
- Some load balancers can be setup as **internal** (private) or **external** (public) ELBs

Load Balancer Security Groups



Load Balancer Security Group:

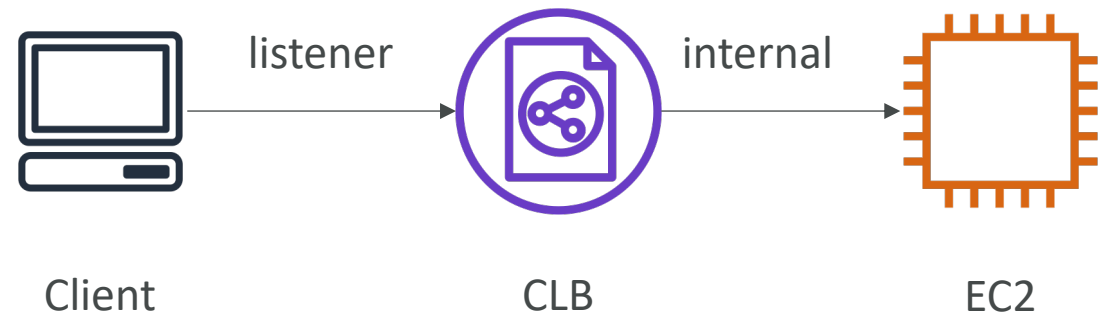
Type ⓘ	Protocol ⓘ	Port Range ⓘ	Source ⓘ	Description ⓘ
HTTP	TCP	80	0.0.0.0/0	Allow HTTP from an...
HTTPS	TCP	443	0.0.0.0/0	Allow HTTPS from a...

Application Security Group: Allow traffic only from Load Balancer

Type ⓘ	Protocol ⓘ	Port Range ⓘ	Source ⓘ	Description ⓘ
HTTP	TCP	80	sg-054b5ff5ea02f2b6e (load-b	Allow Traffic only...

Classic Load Balancers (v1)

- Supports TCP (Layer 4), HTTP & HTTPS (Layer 7)
- Health checks are TCP or HTTP based
- Fixed hostname
XXX.region.elb.amazonaws.com





Application Load Balancer (v2)

- Application load balancers is Layer 7 (HTTP)
- Load balancing to multiple HTTP applications across machines (target groups)
- Load balancing to multiple applications on the same machine (ex: containers)
- Support for HTTP/2 and WebSocket
- Support redirects (from HTTP to HTTPS for example)

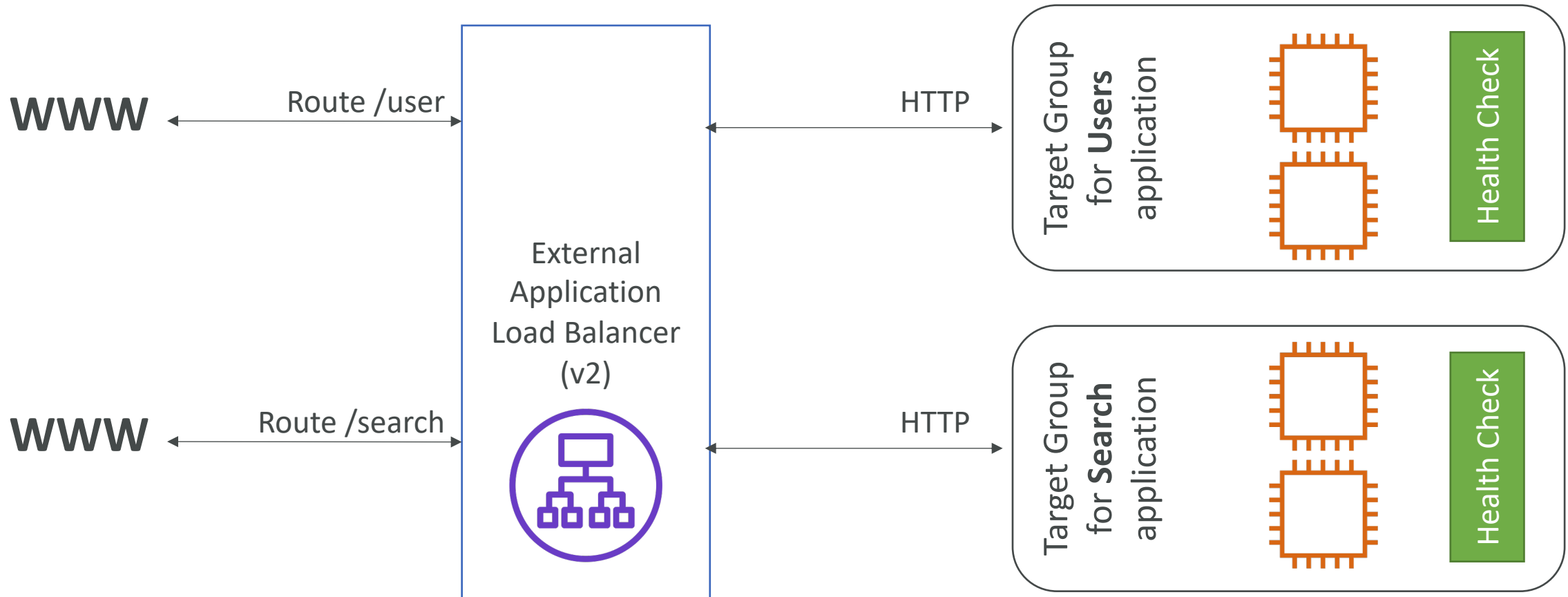


Application Load Balancer (v2)

- Routing tables to different target groups:
 - Routing based on path in URL (example.com/[users](#) & example.com/[posts](#))
 - Routing based on hostname in URL ([one.example.com](#) & [other.example.com](#))
 - Routing based on Query String, Headers (example.com/users?[id=123&order=false](#))
- ALB are a great fit for micro services & container-based application (example: Docker & Amazon ECS)
- Has a port mapping feature to redirect to a dynamic port in ECS
- In comparison, we'd need multiple Classic Load Balancer per application

Application Load Balancer (v2)

HTTP Based Traffic



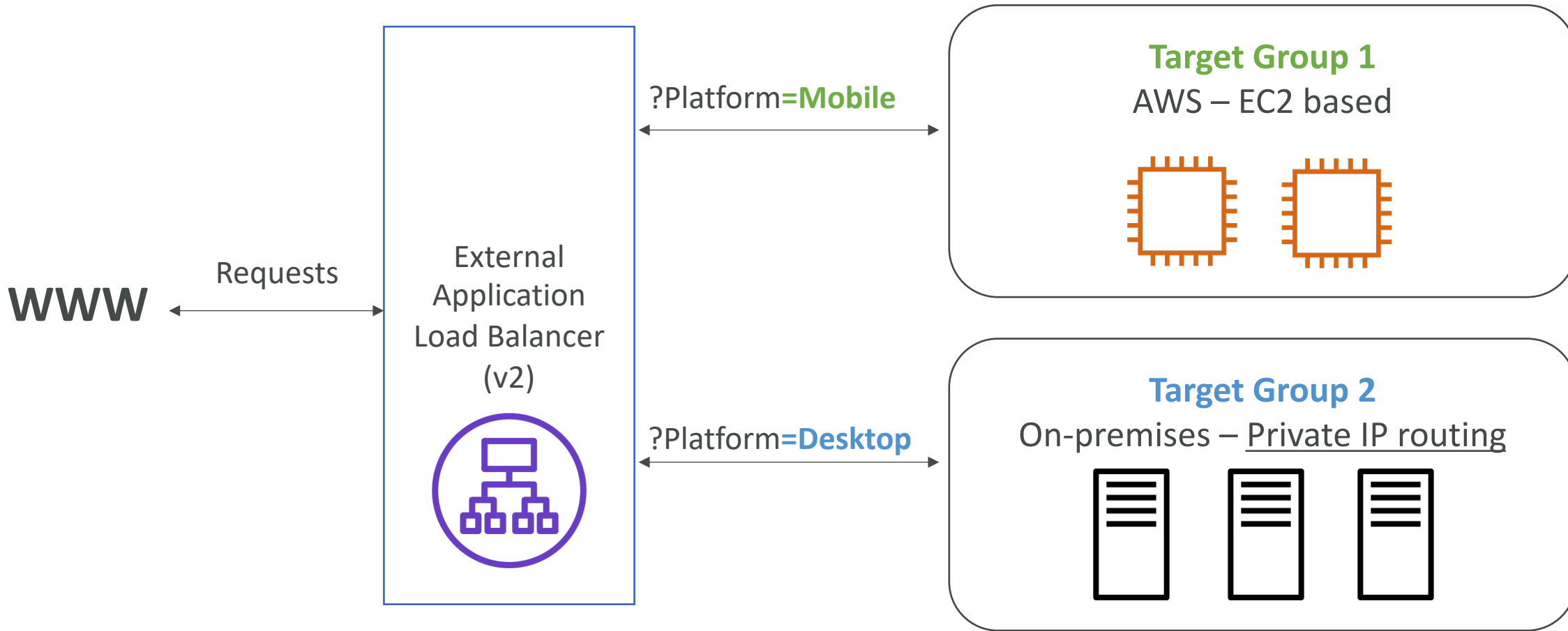
Application Load Balancer (v2)

Target Groups

- EC2 instances (can be managed by an Auto Scaling Group) – HTTP
 - ECS tasks (managed by ECS itself) – HTTP
 - Lambda functions – HTTP request is translated into a JSON event
 - IP Addresses – must be private IPs
-
- ALB can route to multiple target groups
 - Health checks are at the target group level

Application Load Balancer (v2)

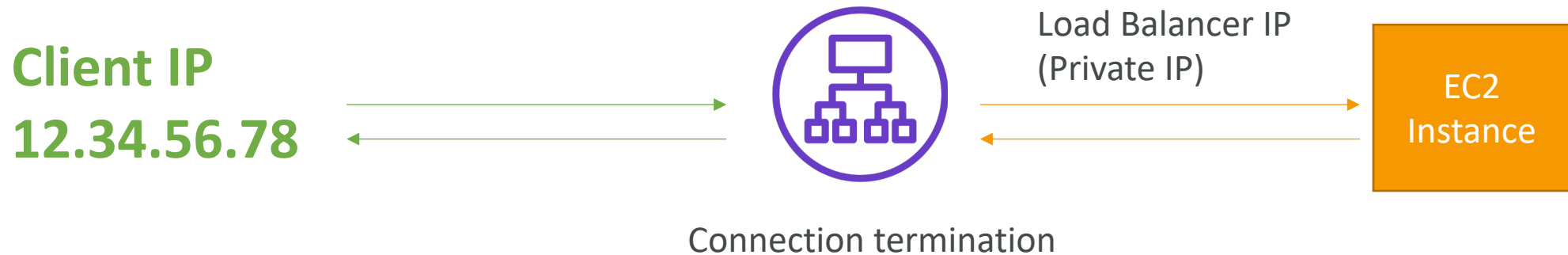
Query Strings/Parameters Routing

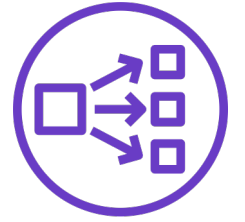


Application Load Balancer (v2)

Good to Know

- Fixed hostname (XXX.region.elb.amazonaws.com)
- The application servers don't see the IP of the client directly
 - The true IP of the client is inserted in the header **X-Forwarded-For**
 - We can also get Port (X-Forwarded-Port) and proto (X-Forwarded-Proto)

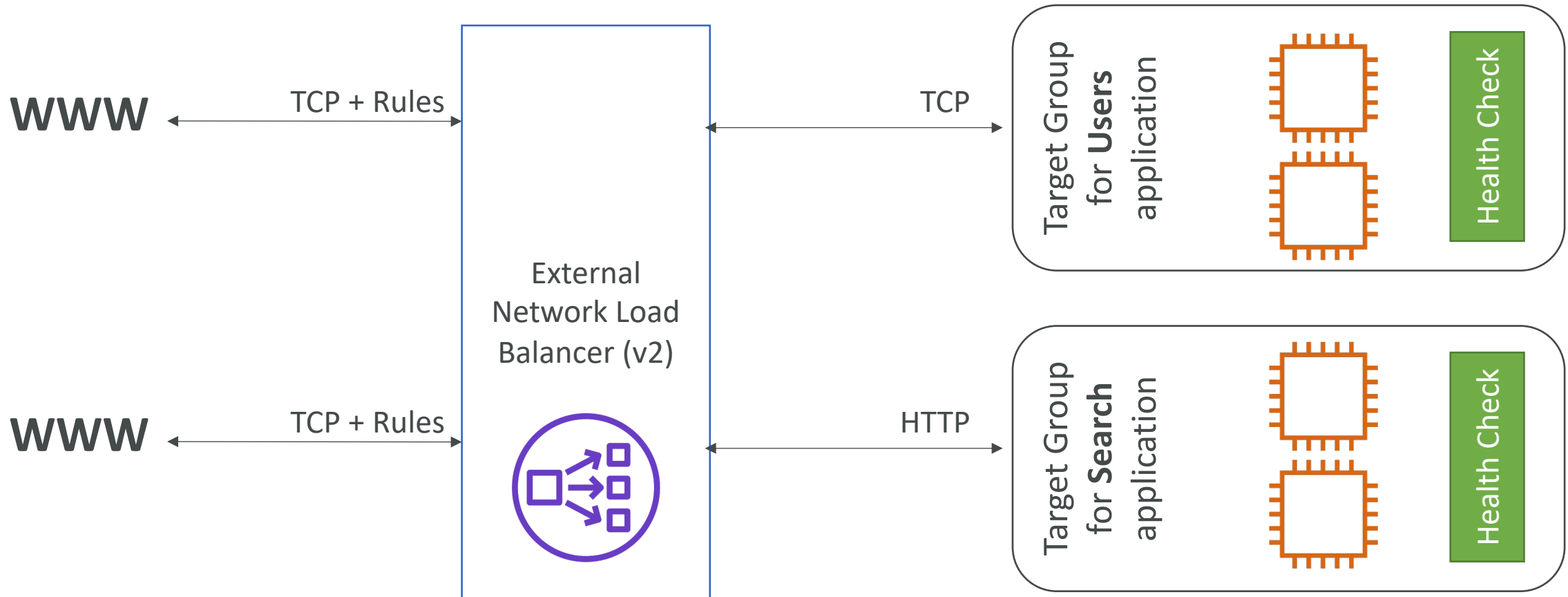




Network Load Balancer (v2)

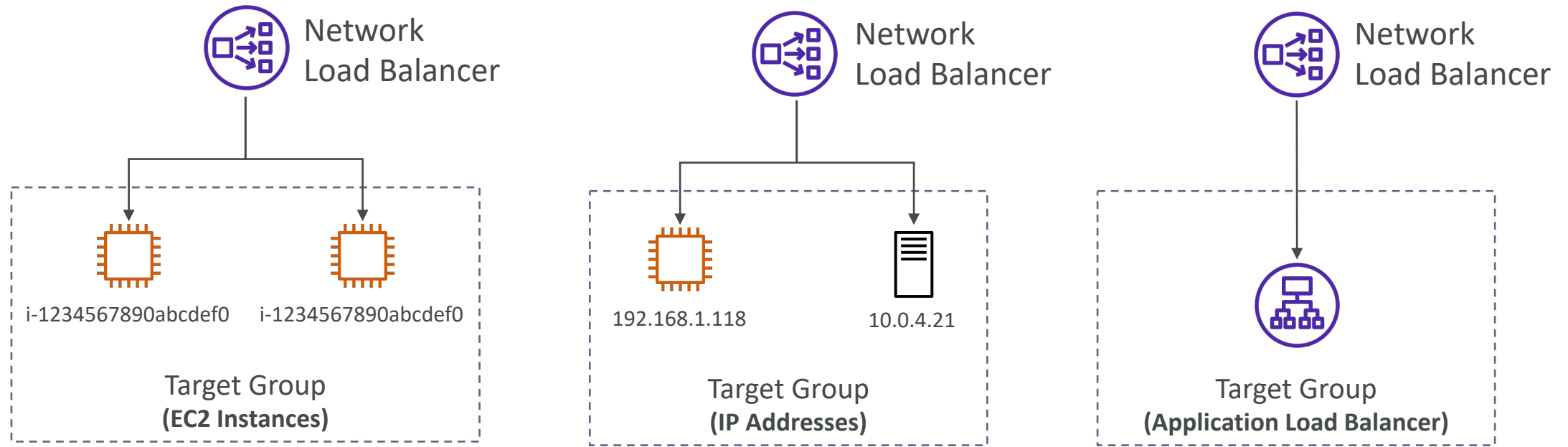
- Network load balancers (Layer 4) allow to:
 - Forward TCP & UDP traffic to your instances
 - Handle millions of request per seconds
 - Ultra-low latency
- NLB has one static IP per AZ, and supports assigning Elastic IP (helpful for whitelisting specific IP)
- NLB are used for extreme performance, TCP or UDP traffic
- Not included in the AWS free tier

Network Load Balancer (v2) TCP (Layer 4) Based Traffic



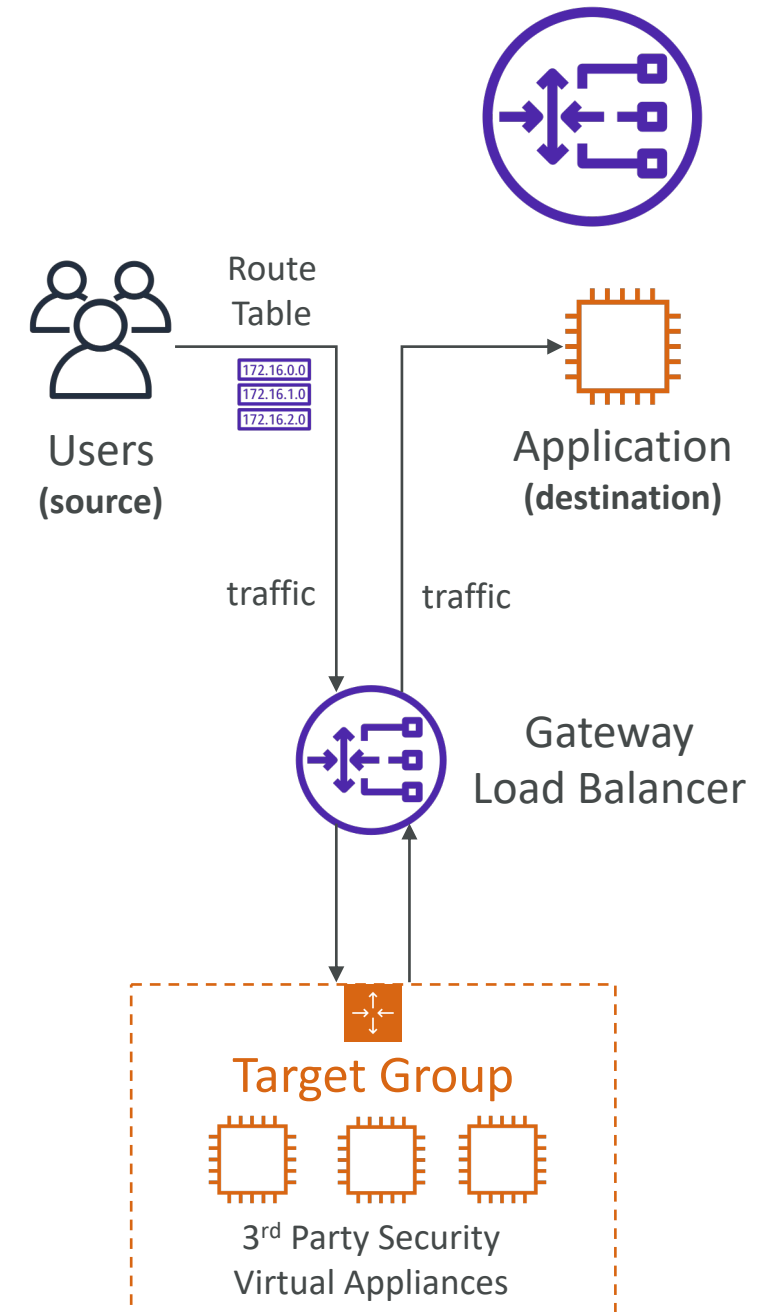
Network Load Balancer – Target Groups

- EC2 instances
- IP Addresses – must be private IPs
- Application Load Balancer
- Health Checks support the TCP, HTTP and HTTPS Protocols



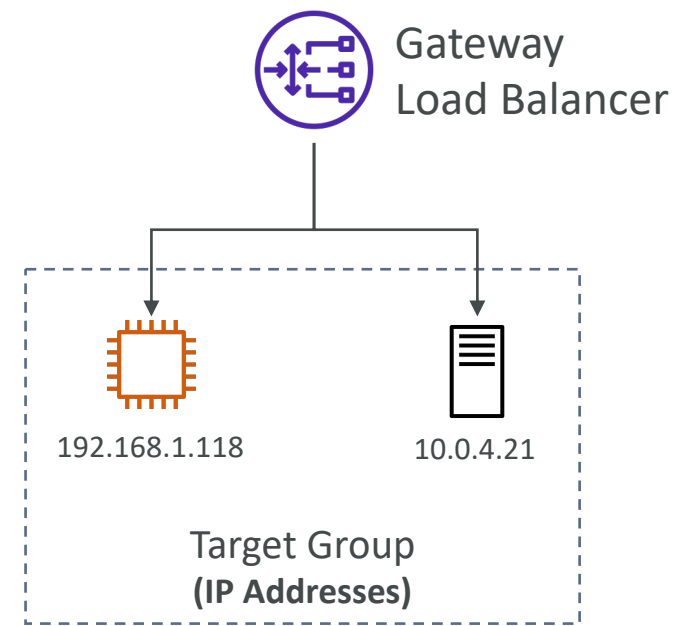
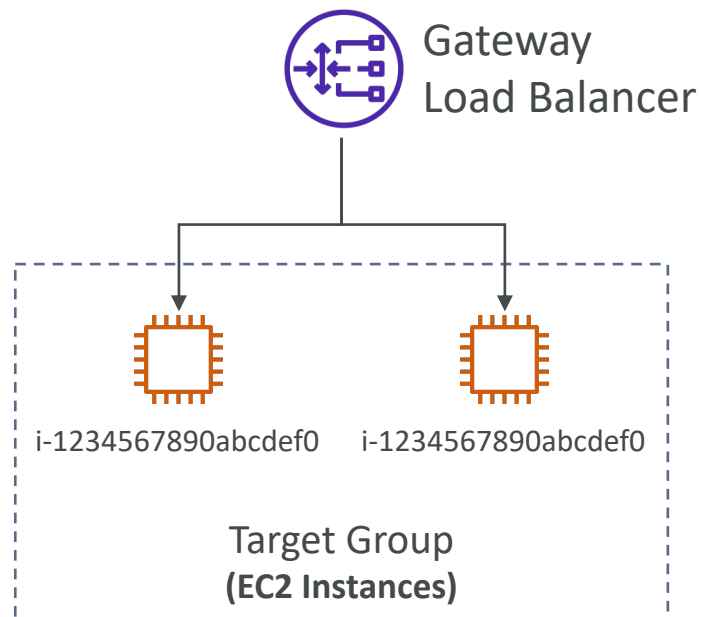
Gateway Load Balancer

- Deploy, scale, and manage a fleet of 3rd party network virtual appliances in AWS
- Example: Firewalls, Intrusion Detection and Prevention Systems, Deep Packet Inspection Systems, payload manipulation, ...
- Operates at Layer 3 (Network Layer) – IP Packets
- Combines the following functions:
 - **Transparent Network Gateway** – single entry/exit for all traffic
 - **Load Balancer** – distributes traffic to your virtual appliances
- Uses the **GENEVE** protocol on port 6081



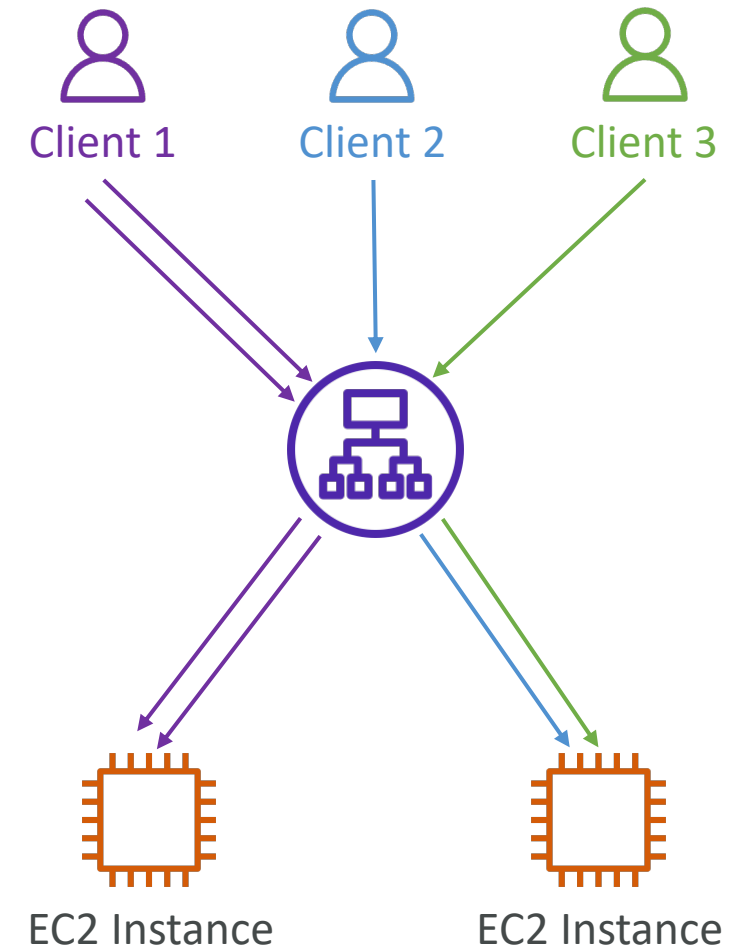
Gateway Load Balancer – Target Groups

- EC2 instances
- IP Addresses – must be private IPs



Sticky Sessions (Session Affinity)

- It is possible to implement stickiness so that the same client is always redirected to the same instance behind a load balancer
- This works for **Classic Load Balancer**, **Application Load Balancer**, and **Network Load Balancer**
- For both CLB & ALB, the “cookie” used for stickiness has an expiration date you control
- Use case: make sure the user doesn't lose his session data
- Enabling stickiness may bring imbalance to the load over the backend EC2 instances



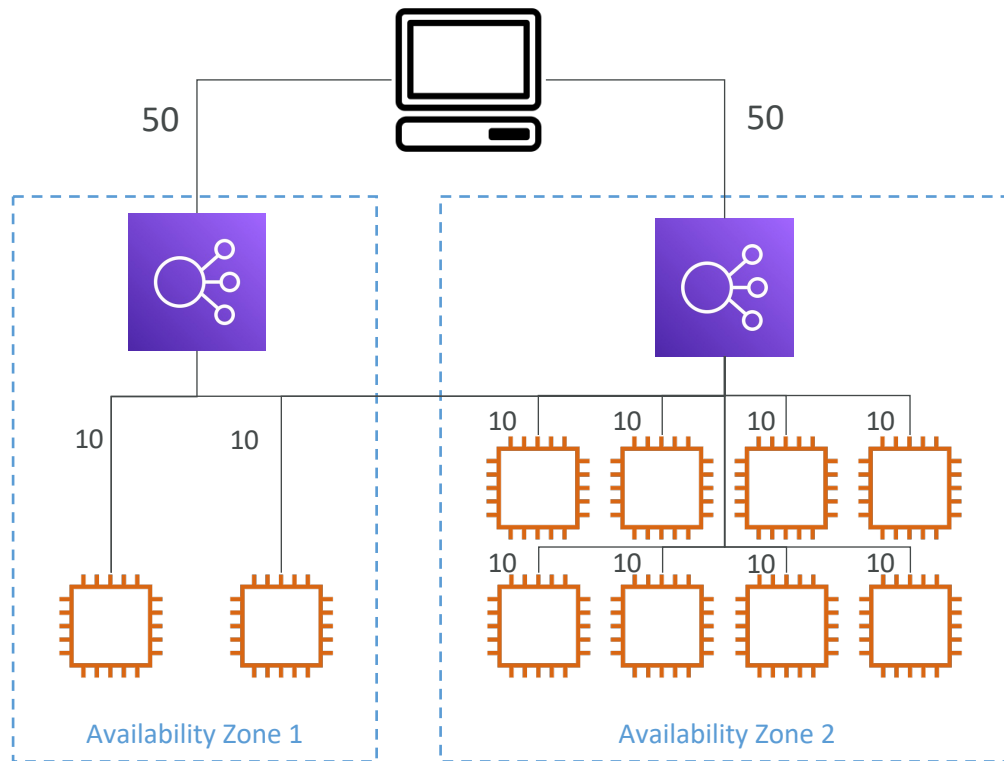
Sticky Sessions – Cookie Names

- Application-based Cookies
 - Custom cookie
 - Generated by the target
 - Can include any custom attributes required by the application
 - Cookie name must be specified individually for each target group
 - Don't use **AWSALB**, **AWSALBAPP**, or **AWSALBTG** (reserved for use by the ELB)
 - Application cookie
 - Generated by the load balancer
 - Cookie name is **AWSALBAPP**
- Duration-based Cookies
 - Cookie generated by the load balancer
 - Cookie name is **AWSALB** for ALB, **AWSELB** for CLB

Cross-Zone Load Balancing

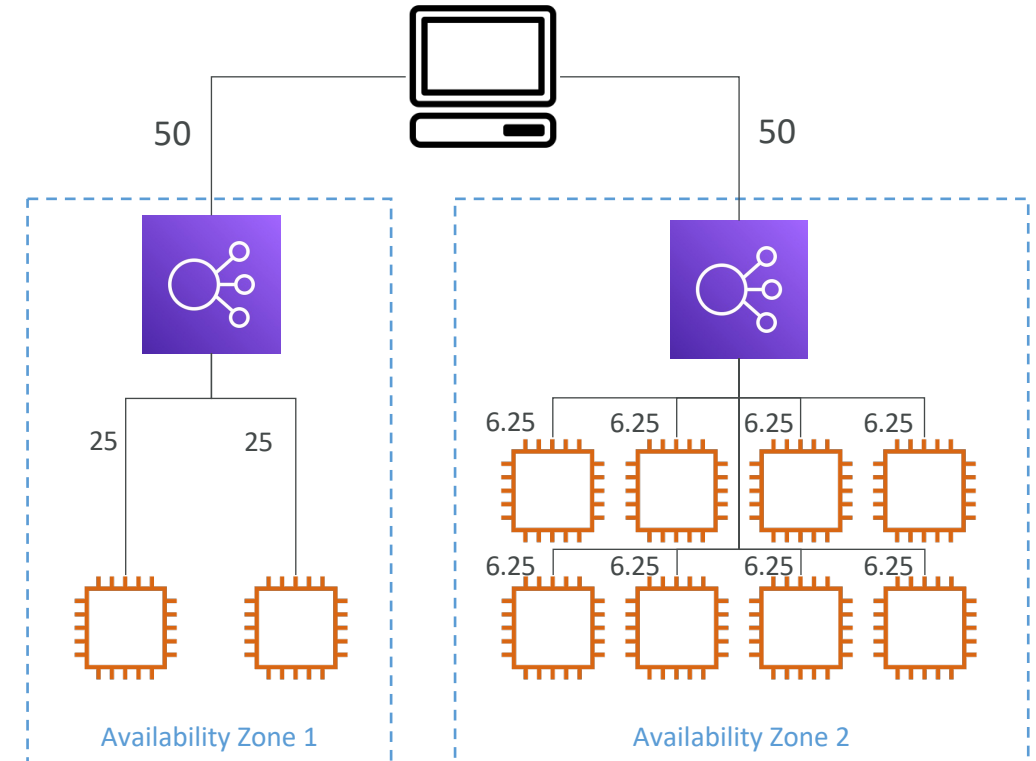
With Cross Zone Load Balancing:

each load balancer instance distributes evenly across all registered instances in all AZ



Without Cross Zone Load Balancing:

Requests are distributed in the instances of the node of the Elastic Load Balancer



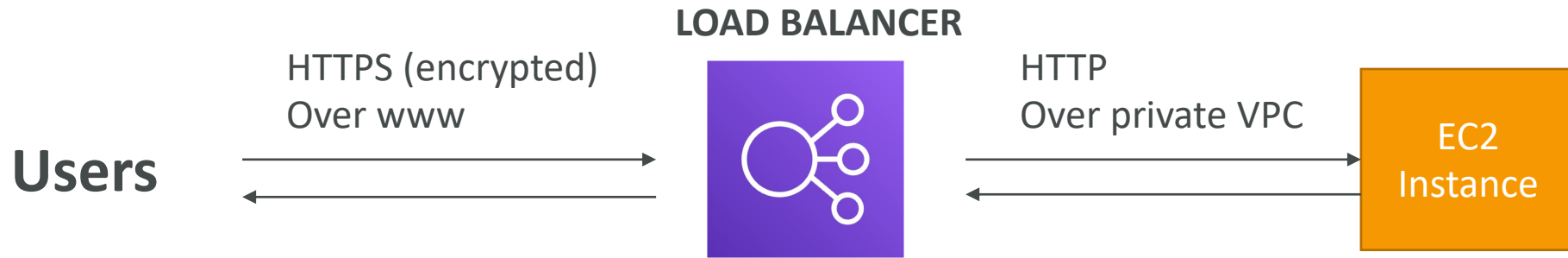
Cross-Zone Load Balancing

- **Application Load Balancer**
 - Enabled by default (can be disabled at the Target Group level)
 - No charges for inter AZ data
- **Network Load Balancer & Gateway Load Balancer**
 - Disabled by default
 - You pay charges (\$) for inter AZ data if enabled
- **Classic Load Balancer**
 - Disabled by default
 - No charges for inter AZ data if enabled

SSL/TLS - Basics

- An SSL Certificate allows traffic between your clients and your load balancer to be encrypted in transit (in-flight encryption)
- **SSL** refers to Secure Sockets Layer, used to encrypt connections
- **TLS** refers to Transport Layer Security, which is a newer version
- Nowadays, **TLS certificates are mainly used**, but people still refer as SSL
- Public SSL certificates are issued by Certificate Authorities (CA)
- Comodo, Symantec, GoDaddy, GlobalSign, Digicert, Letsencrypt, etc...
- SSL certificates have an expiration date (you set) and must be renewed

Load Balancer - SSL Certificates



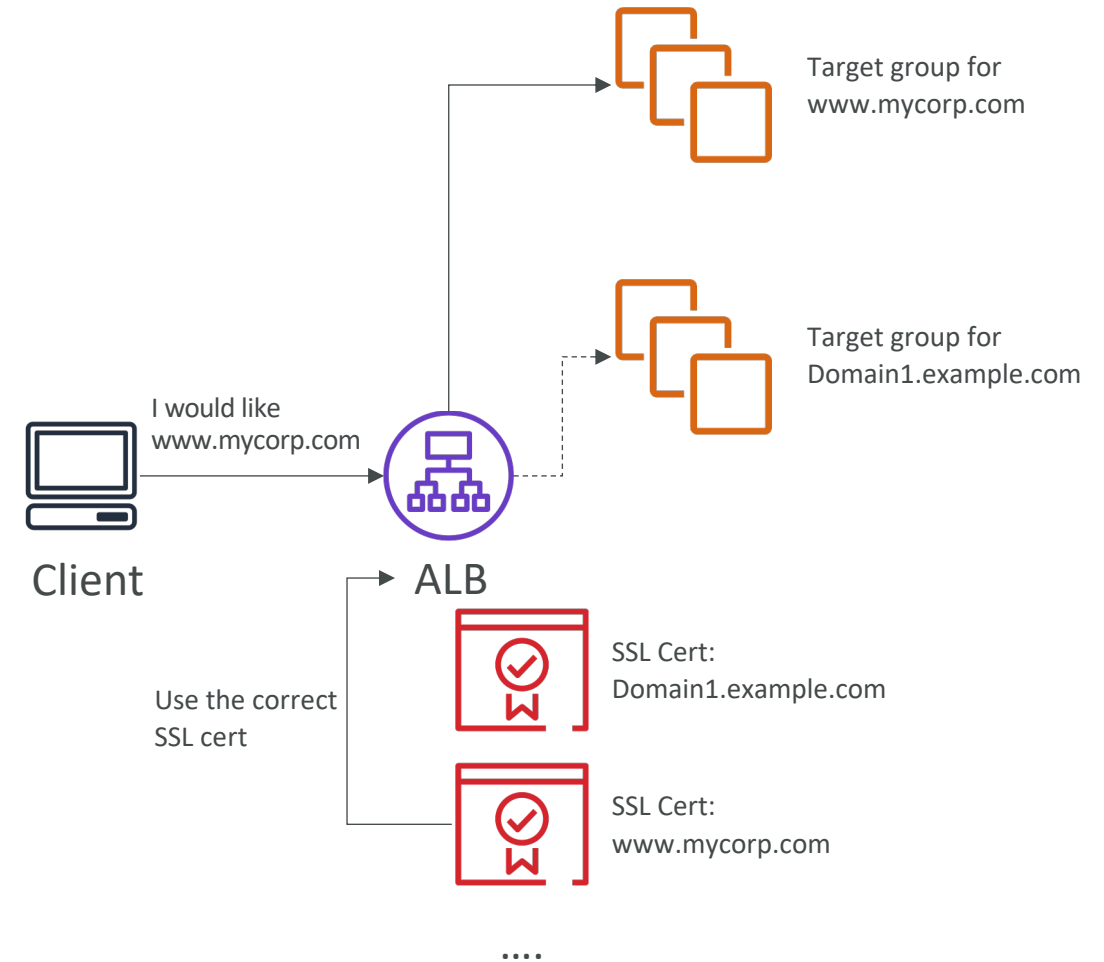
- The load balancer uses an X.509 certificate (SSL/TLS server certificate)
- You can manage certificates using ACM (AWS Certificate Manager)
- You can create upload your own certificates alternatively
- HTTPS listener:
 - You must specify a default certificate
 - You can add an optional list of certs to support multiple domains
 - **Clients can use SNI (Server Name Indication) to specify the hostname they reach**
 - Ability to specify a security policy to support older versions of SSL / TLS (legacy clients)

SSL – Server Name Indication (SNI)

- SNI solves the problem of loading **multiple SSL certificates onto one web server** (to serve multiple websites)
- It's a “newer” protocol, and requires the client to **indicate** the hostname of the target server in the initial SSL handshake
- The server will then find the correct certificate, or return the default one

Note:

- Only works for ALB & NLB (newer generation), CloudFront
- Does not work for CLB (older gen)

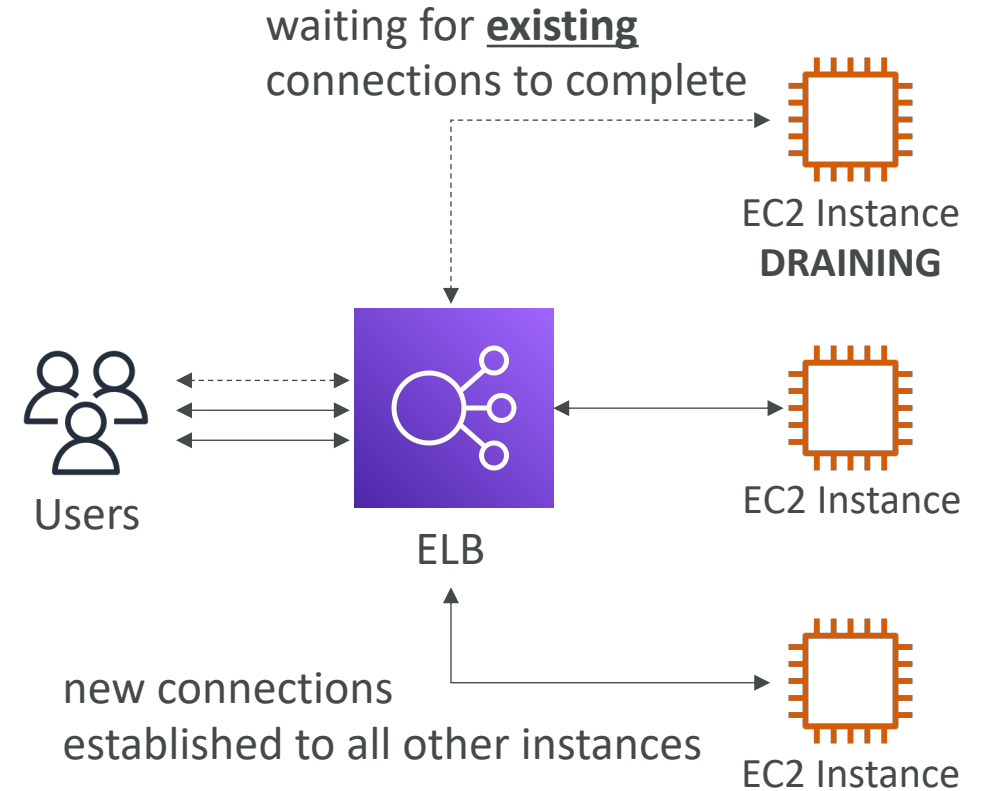


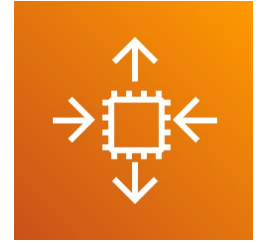
Elastic Load Balancers – SSL Certificates

- **Classic Load Balancer (v1)**
 - Support only one SSL certificate
 - Must use multiple CLB for multiple hostname with multiple SSL certificates
- **Application Load Balancer (v2)**
 - Supports multiple listeners with multiple SSL certificates
 - Uses Server Name Indication (SNI) to make it work
- **Network Load Balancer (v2)**
 - Supports multiple listeners with multiple SSL certificates
 - Uses Server Name Indication (SNI) to make it work

Connection Draining

- **Feature naming**
 - Connection Draining – for CLB
 - Deregistration Delay – for ALB & NLB
- Time to complete “in-flight requests” while the instance is de-registering or unhealthy
- Stops sending new requests to the EC2 instance which is de-registering
- Between 1 to 3600 seconds (default: 300 seconds)
- Can be disabled (set value to 0)
- Set to a low value if your requests are short

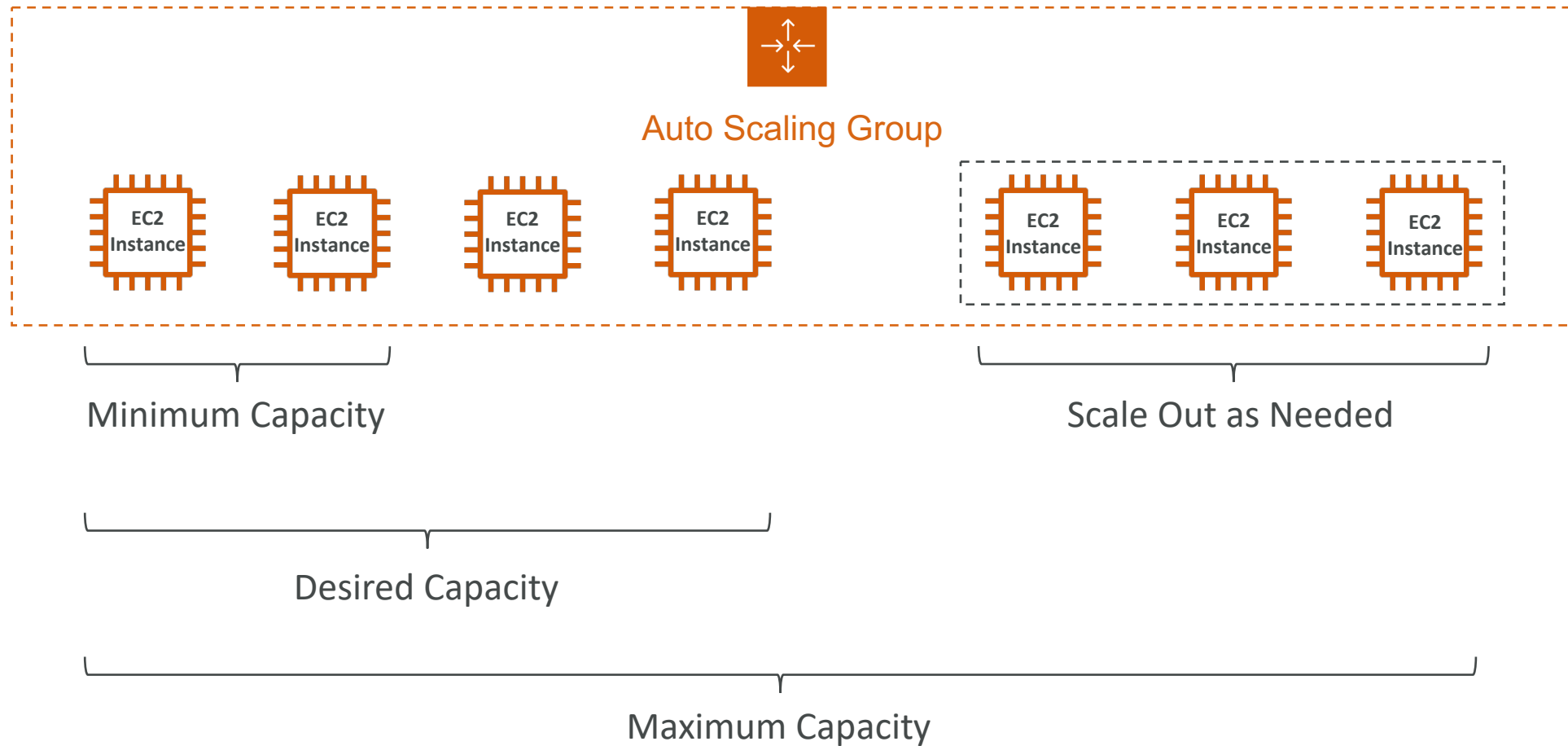




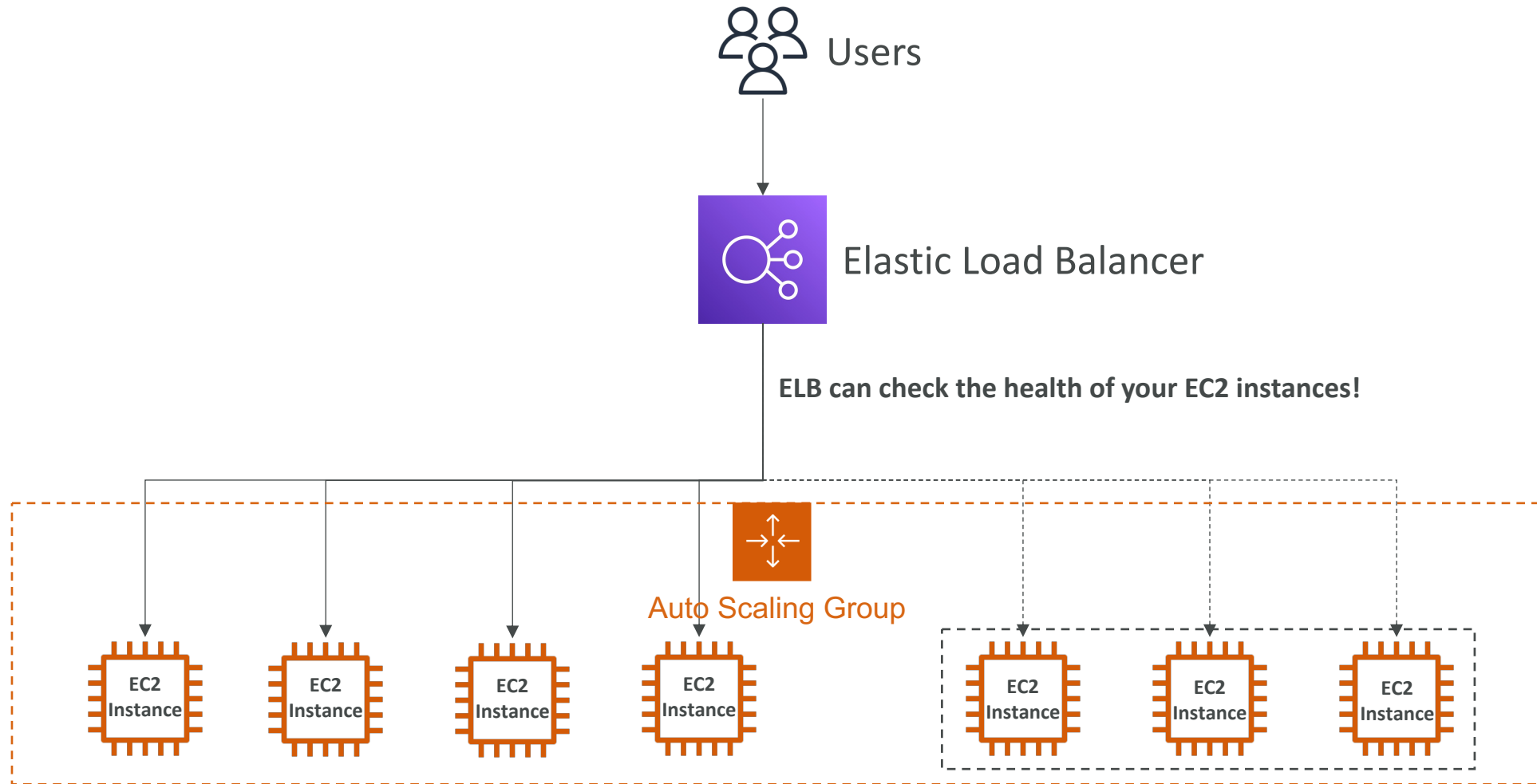
What's an Auto Scaling Group?

- In real-life, the load on your websites and application can change
- In the cloud, you can create and get rid of servers very quickly
- The goal of an Auto Scaling Group (ASG) is to:
 - Scale out (add EC2 instances) to match an increased load
 - Scale in (remove EC2 instances) to match a decreased load
 - Ensure we have a minimum and a maximum number of EC2 instances running
 - Automatically register new instances to a load balancer
 - Re-create an EC2 instance in case a previous one is terminated (ex: if unhealthy)
- ASG are free (you only pay for the underlying EC2 instances)

Auto Scaling Group in AWS

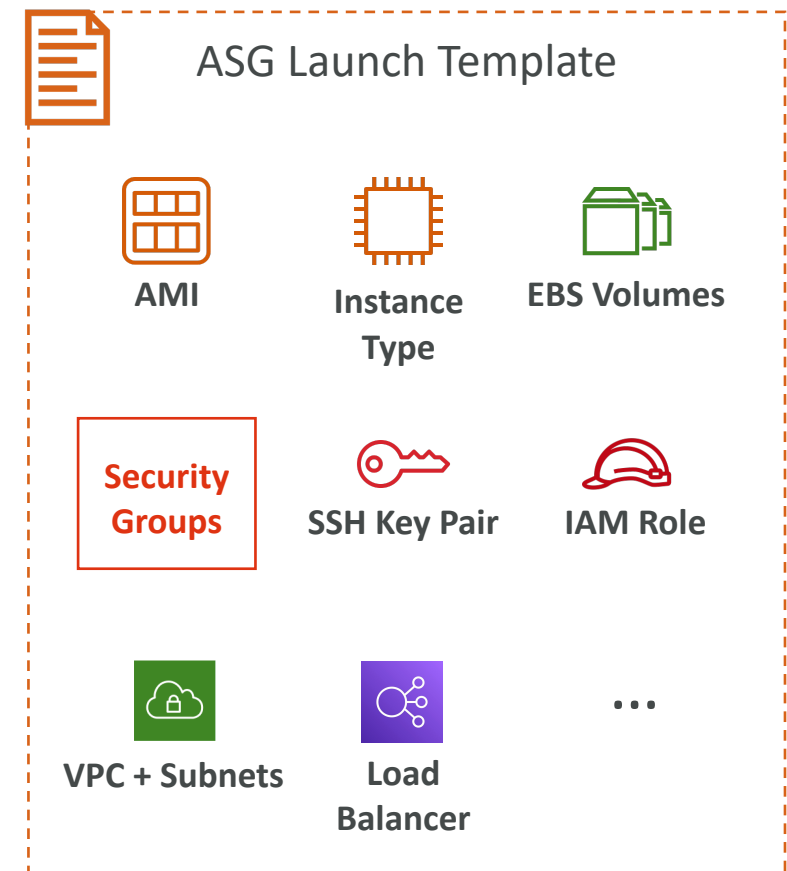


Auto Scaling Group in AWS With Load Balancer



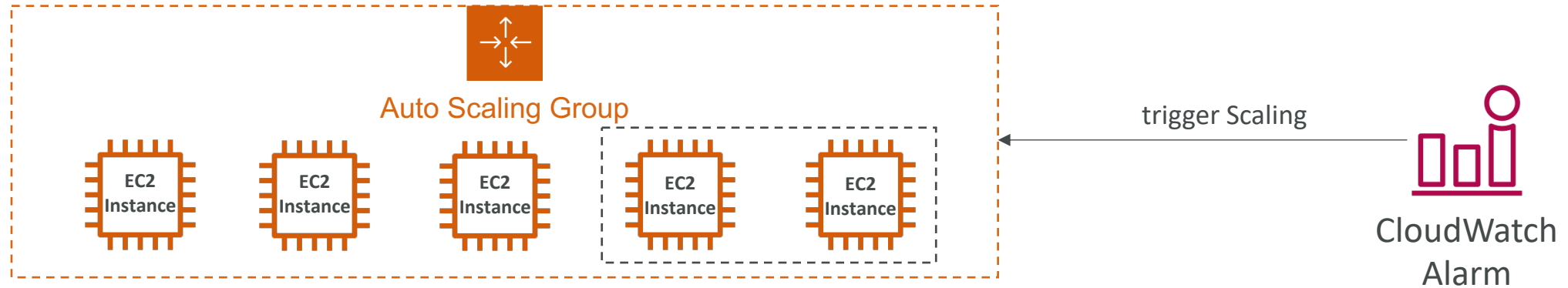
Auto Scaling Group Attributes

- A **Launch Template** (older “Launch Configurations” are deprecated)
 - AMI + Instance Type
 - EC2 User Data
 - EBS Volumes
 - Security Groups
 - SSH Key Pair
 - IAM Roles for your EC2 Instances
 - Network + Subnets Information
 - Load Balancer Information
- Min Size / Max Size / Initial Capacity
- Scaling Policies



Auto Scaling - CloudWatch Alarms & Scaling

- It is possible to scale an ASG based on CloudWatch alarms
- An alarm monitors a metric (such as **Average CPU**, or a **custom metric**)
- Metrics such as Average CPU are computed for the overall ASG instances
- Based on the alarm:
 - We can create scale-out policies (increase the number of instances)
 - We can create scale-in policies (decrease the number of instances)

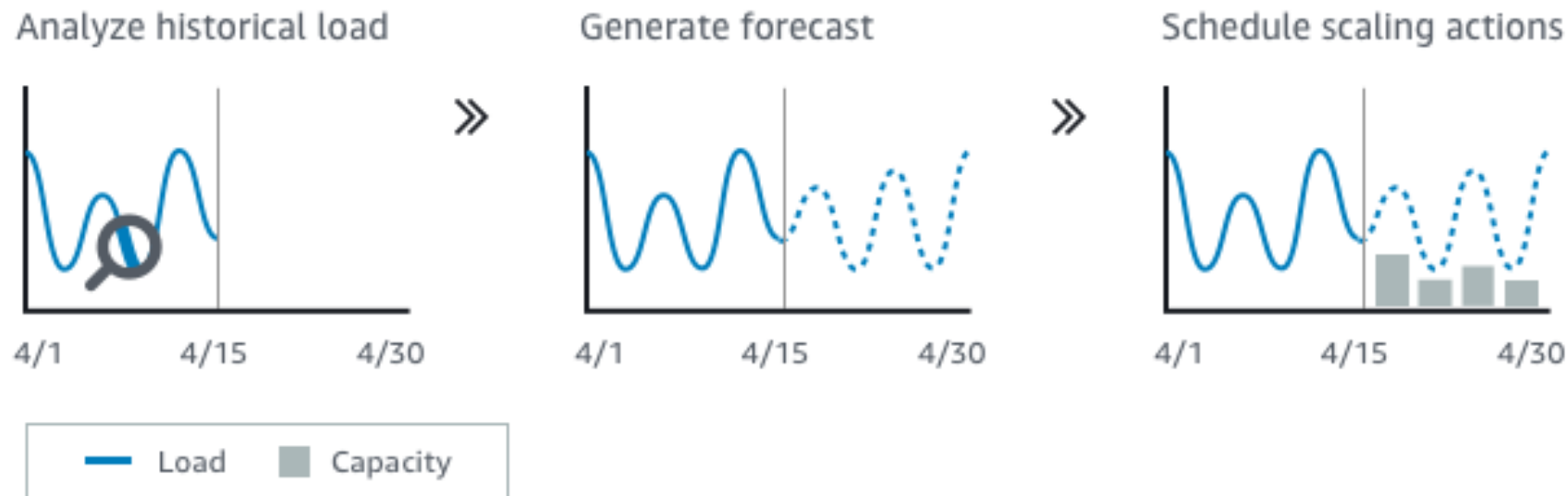


Auto Scaling Groups – Scaling Policies

- **Dynamic Scaling**
 - **Target Tracking Scaling**
 - Simple to set-up
 - Example: I want the average ASG CPU to stay at around 40%
 - **Simple / Step Scaling**
 - When a CloudWatch alarm is triggered (example CPU > 70%), then add 2 units
 - When a CloudWatch alarm is triggered (example CPU < 30%), then remove 1
- **Scheduled Scaling**
 - Anticipate a scaling based on known usage patterns
 - Example: increase the min capacity to 10 at 5 pm on Fridays

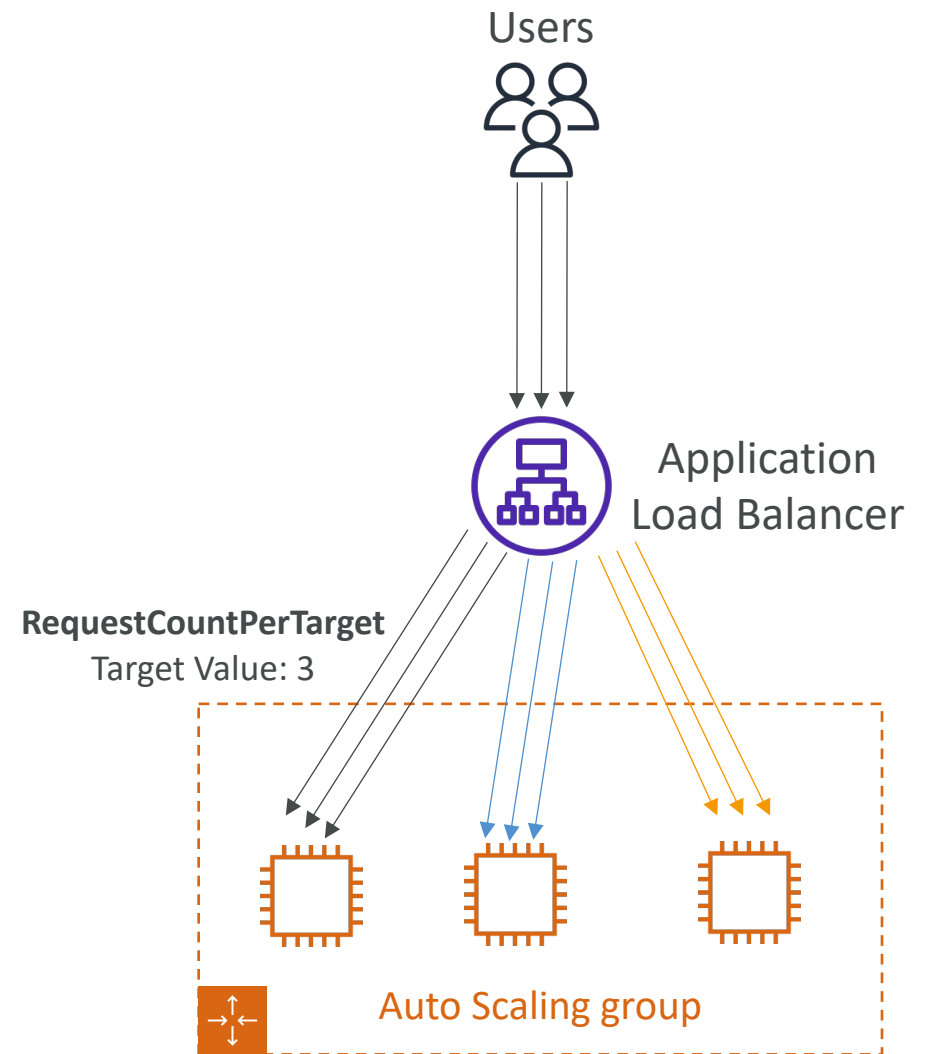
Auto Scaling Groups – Scaling Policies

- **Predictive scaling:** continuously forecast load and schedule scaling ahead



Good metrics to scale on

- **CPUUtilization:** Average CPU utilization across your instances
- **RequestCountPerTarget:** to make sure the number of requests per EC2 instances is stable
- **Average Network In / Out** (if you're application is network bound)
- **Any custom metric** (that you push using CloudWatch)



Auto Scaling Groups - Scaling Cooldowns

- After a scaling activity happens, you are in the **cooldown period** (default 300 seconds)
- During the cooldown period, the ASG will not launch or terminate additional instances (to allow for metrics to stabilize)
- Advice: Use a ready-to-use AMI to reduce configuration time in order to be serving request faster and reduce the cooldown period

