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▶ Cloud With Raj



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Instructor Bio:

Sr. Solutions Architect @ 

Bestselling Udemy/Pluralsight author

Tech Advisor of crypto startup

Public speaker and guest lecturer

Author of multiple official AWS blogs

YouTuber with 30K subscribers

Previously - Distinguished Cloud Architect @Verizon

Opinions are my own

SECTION1: SYSTEM DESIGN BASICS

Microservices

The monolith

“...a **single-tiered software application** in which the user interface and data access code are combined into a **single program** from a **single platform**.”

- Wikipedia

Monolith is not the bad guy!

Pros:

- At first...
 - Simple
 - No over-engineering
- Single code base
- Resource efficient at small scale

Cons:

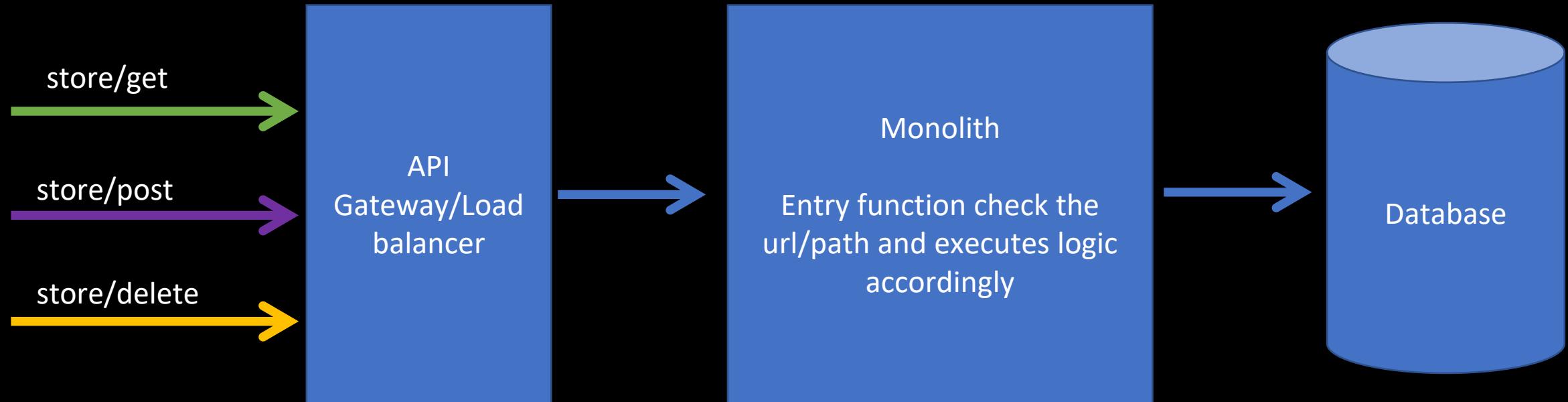
- Modularity is hard to enforce as app grows
- Scaling is a challenge
- All or nothing deployment
- Long release cycles
- Slow to react to customer demand

Can you use API with Monolith?

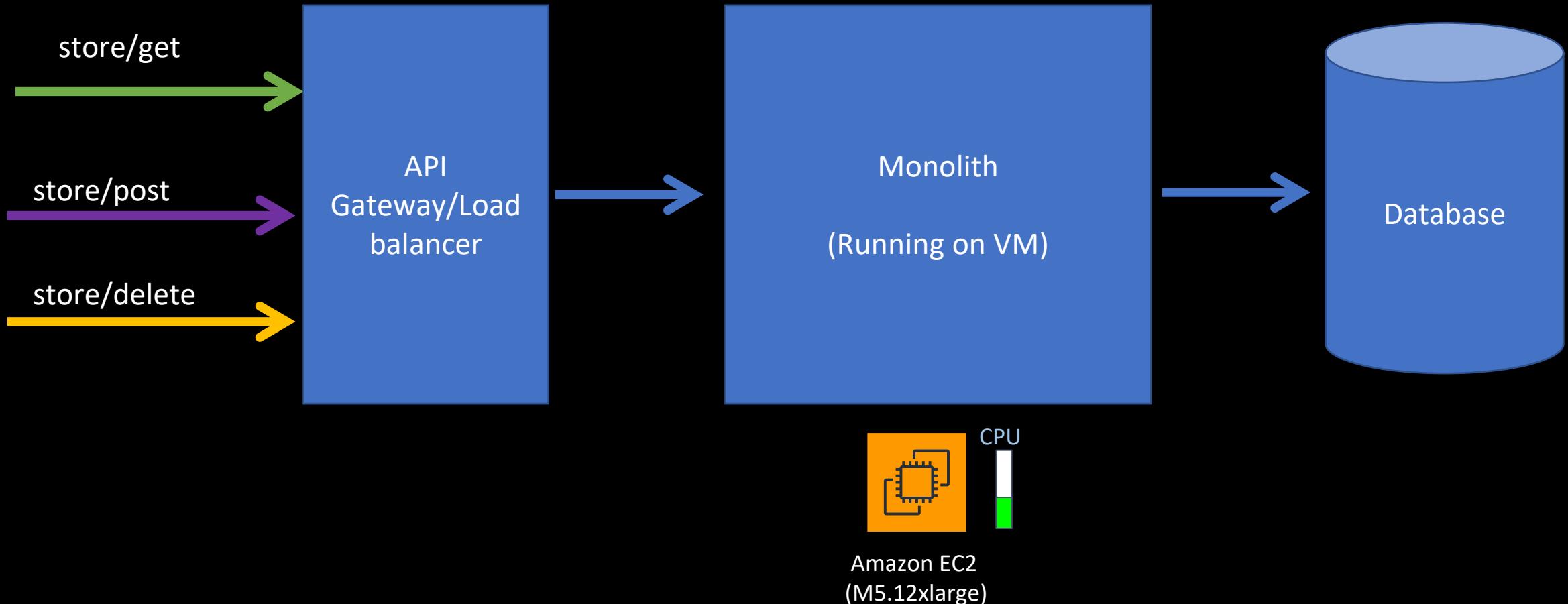
Absolutely

APIs does NOT equal microservices

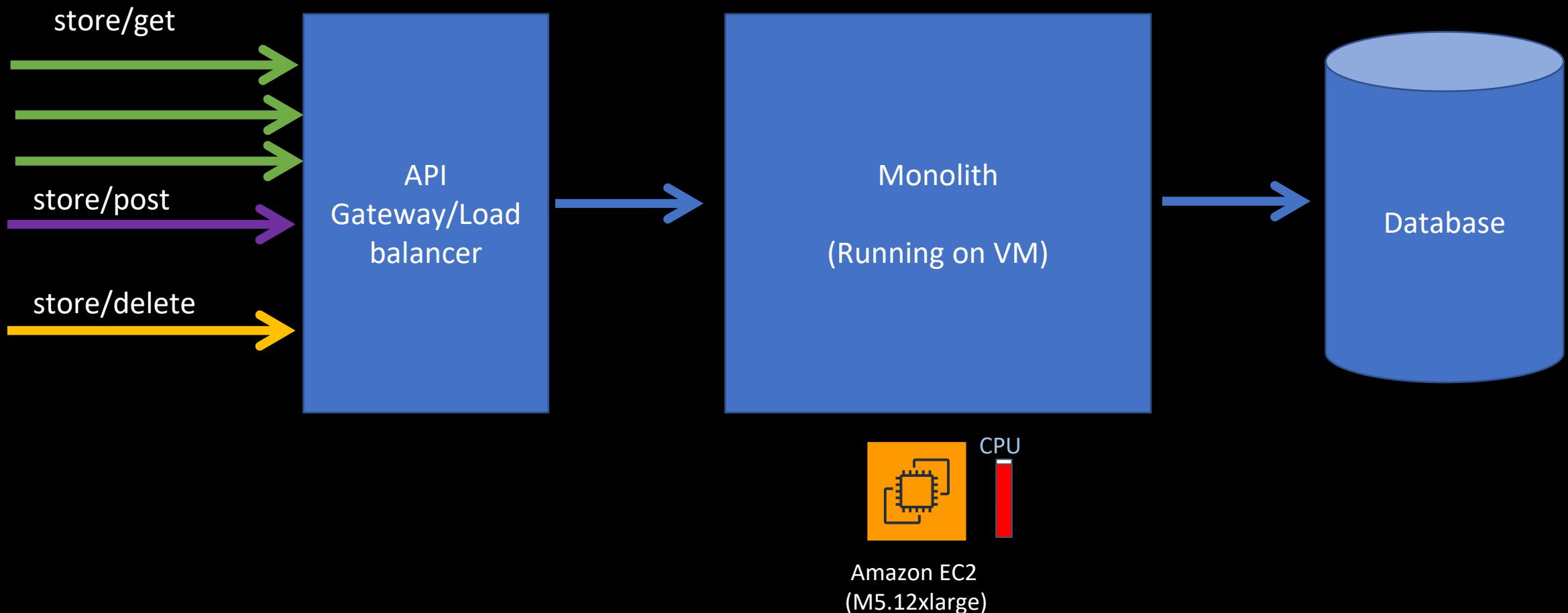
APIs in Monolith



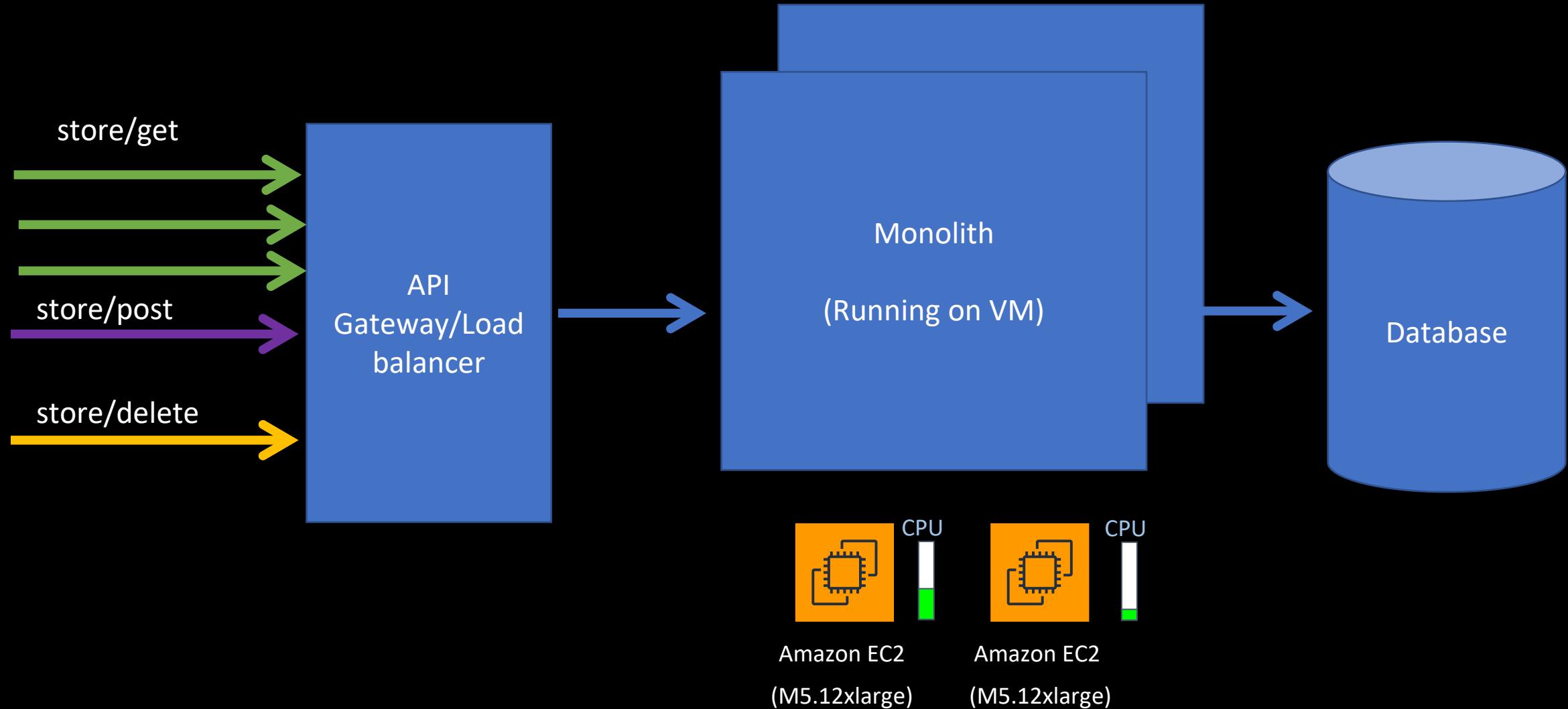
Issue of Scaling



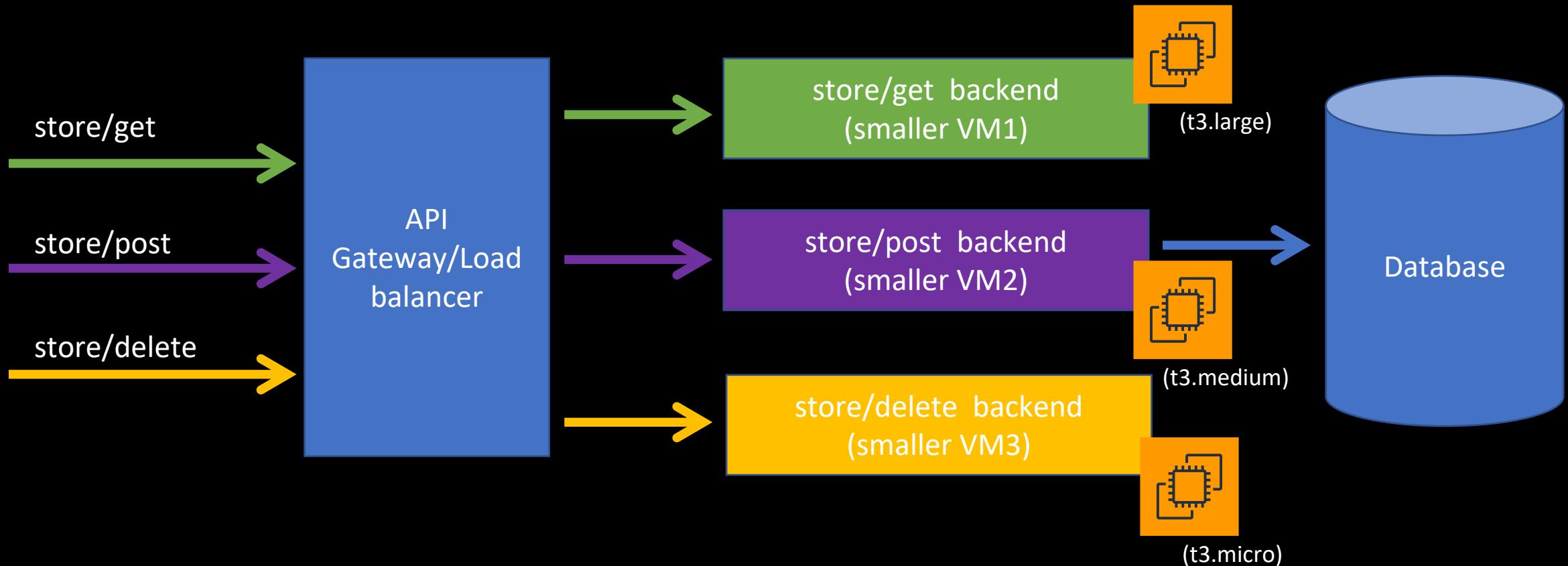
Issue of Scaling



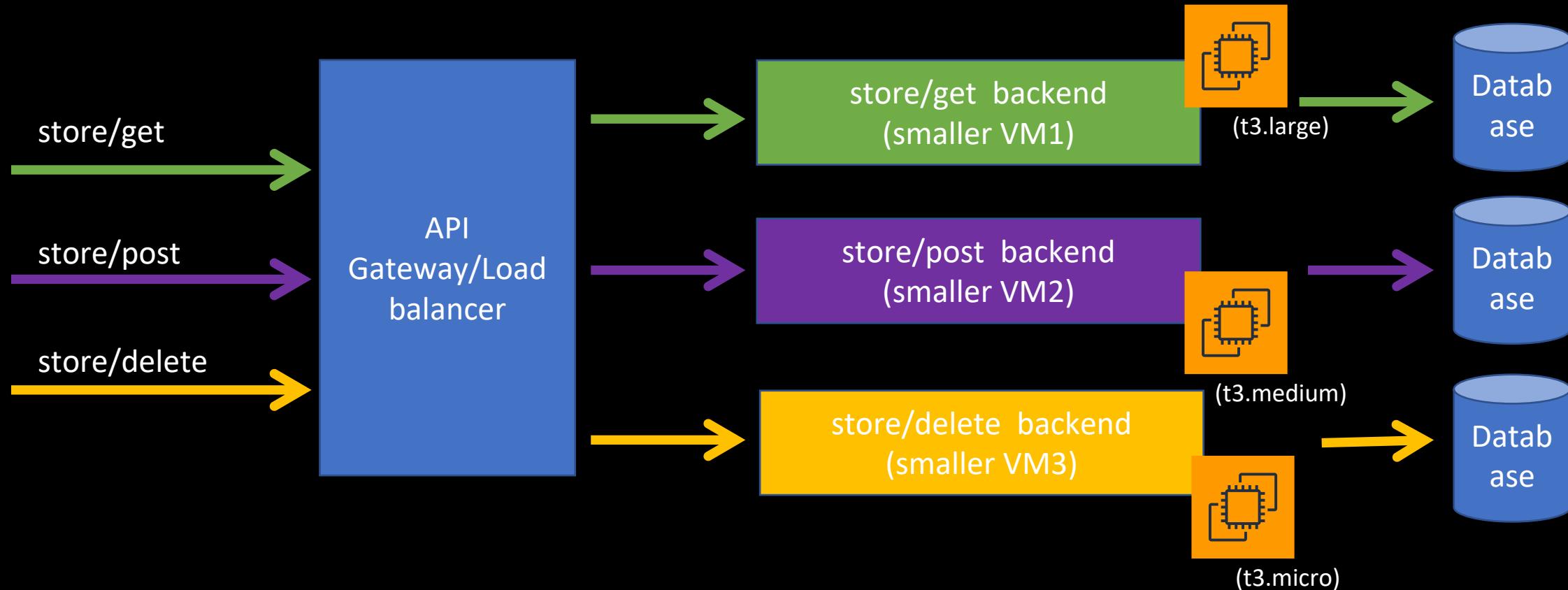
Entire Monolith Need to Scale



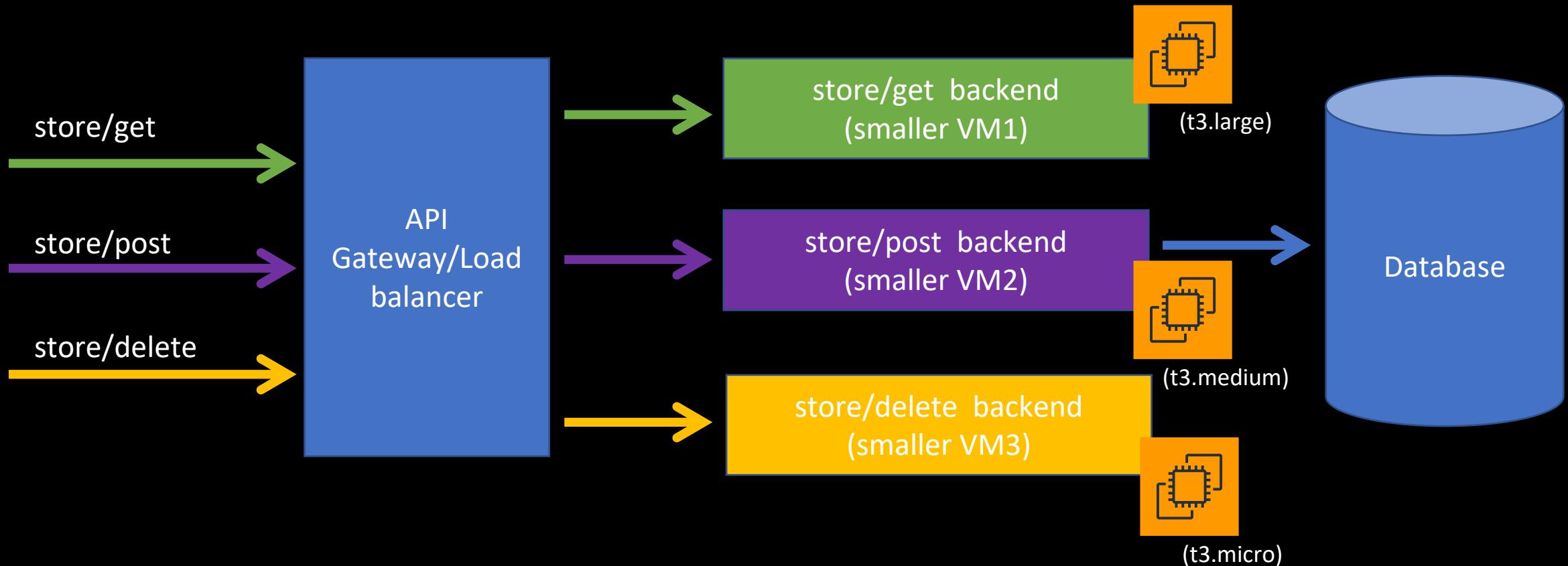
APIs in Microservice



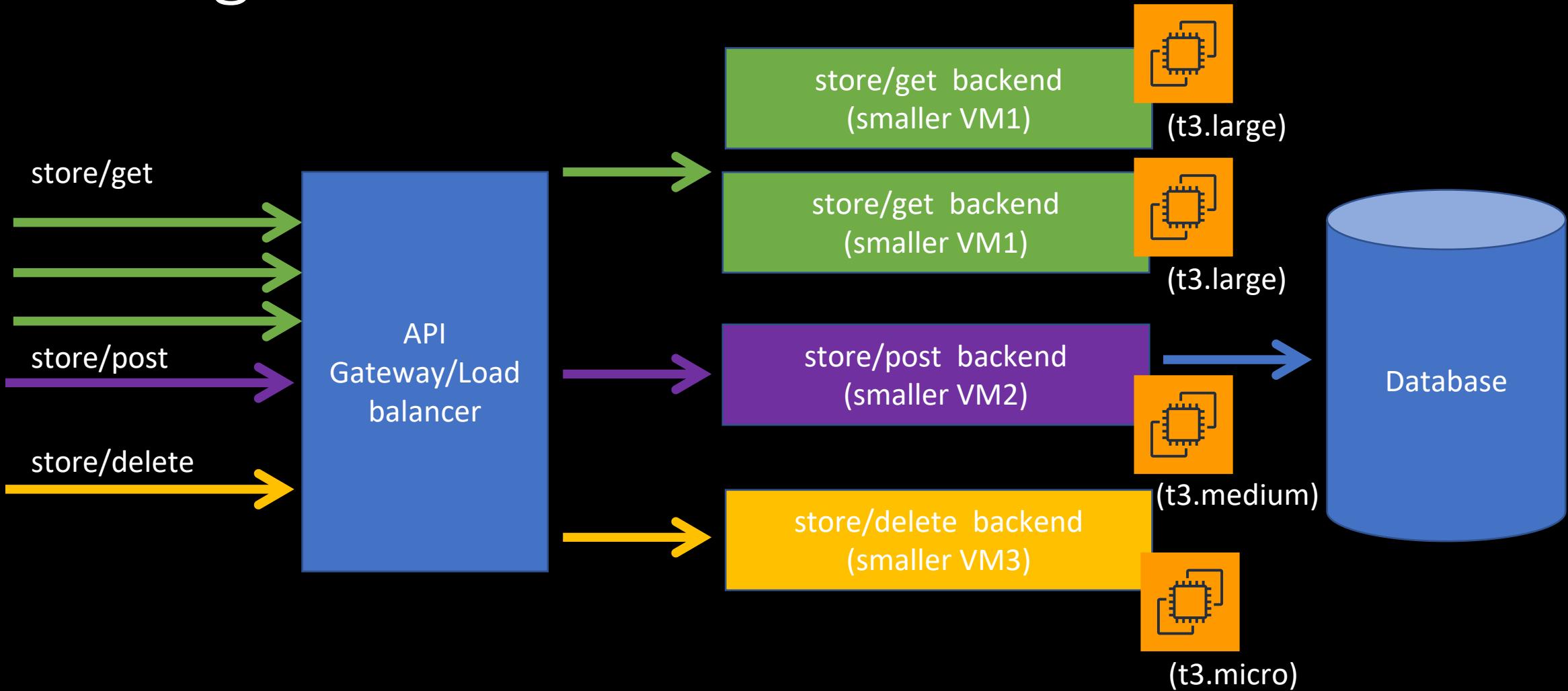
APIs in Microservice



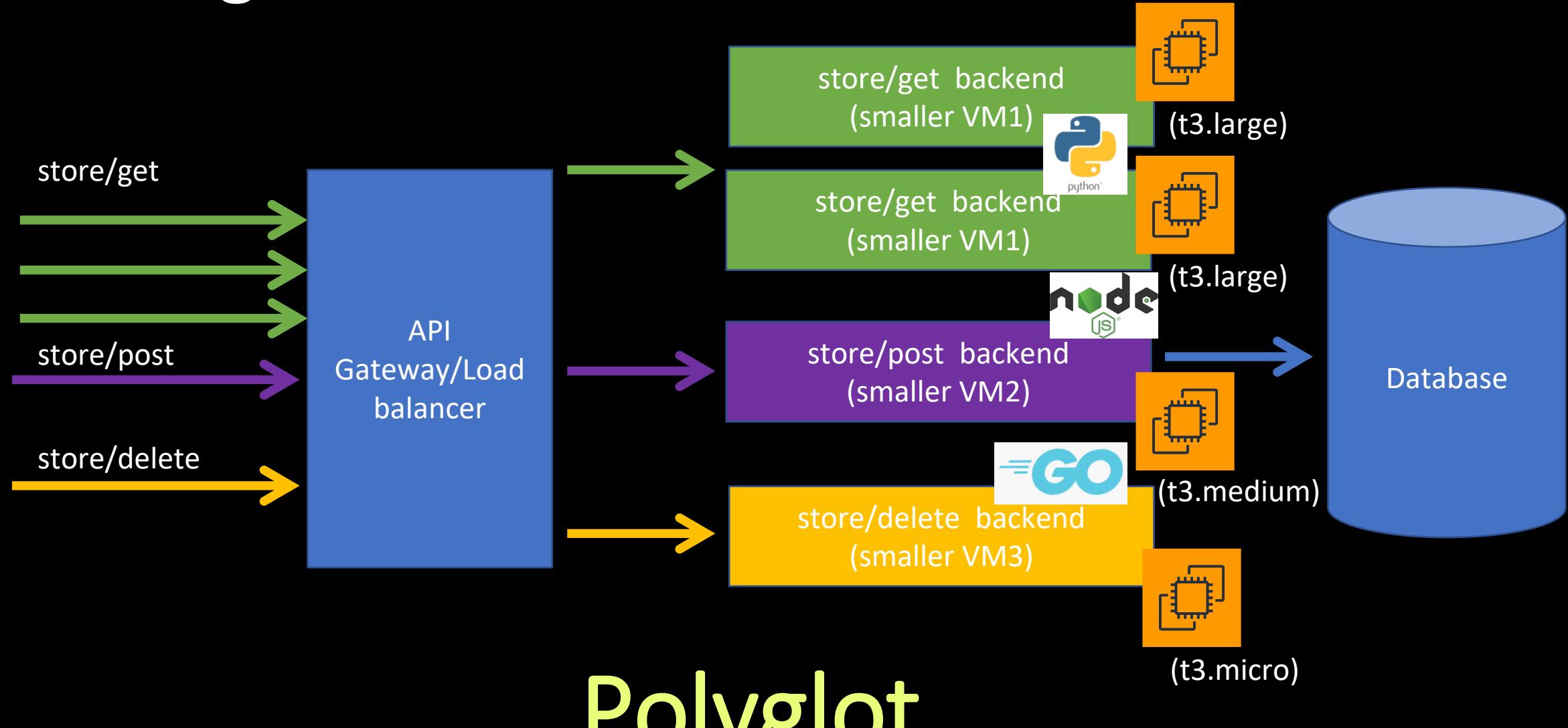
APIs in Microservice



Scaling APIs in Microservice



Scaling APIs in Microservice



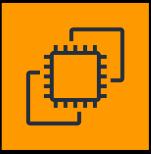
Characteristics of microservice architectures

- Independent
 - Scaling
 - Governance
 - Deployment
 - Testing
 - Functionality

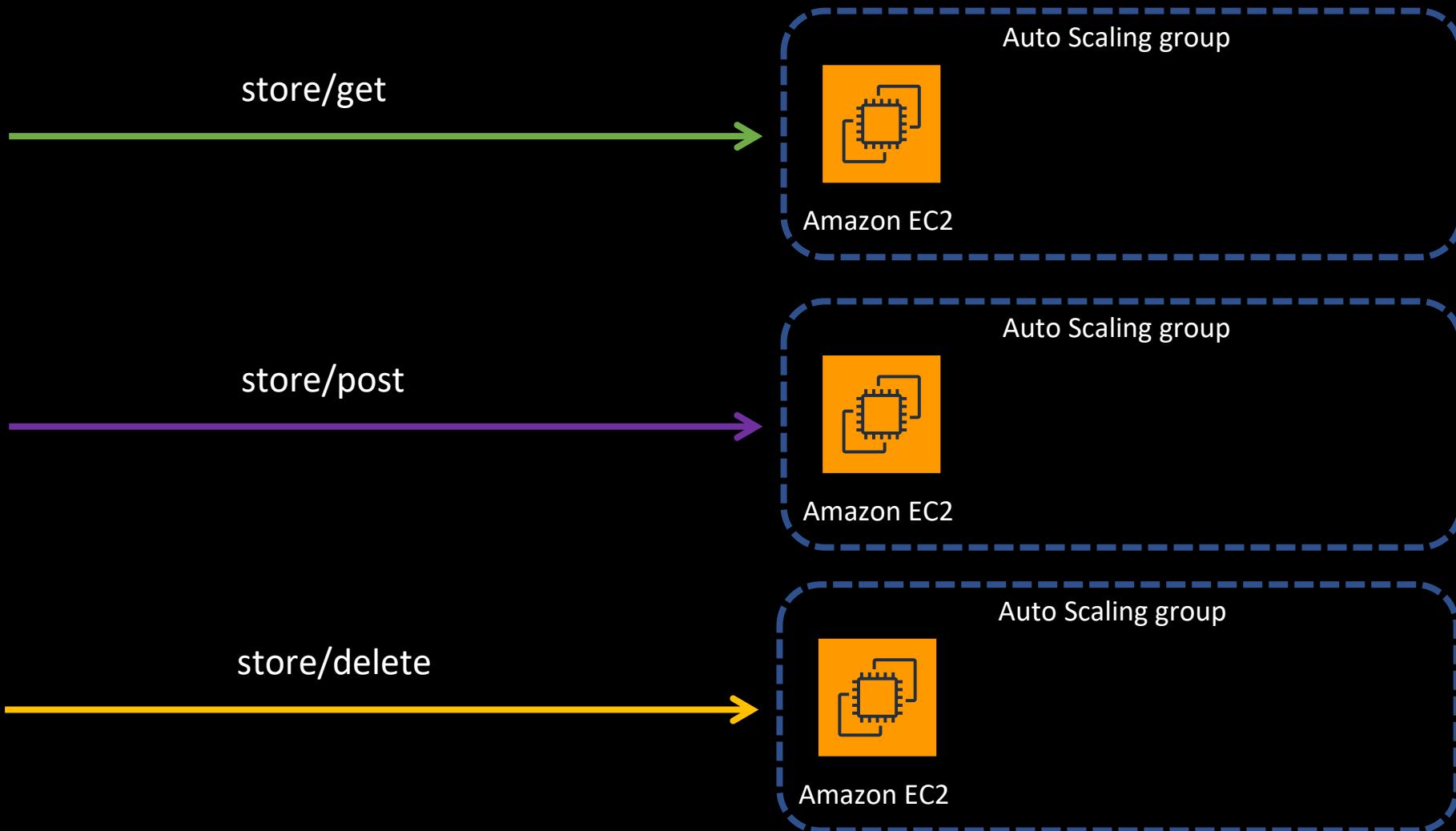
Important - Not required to follow every characteristic

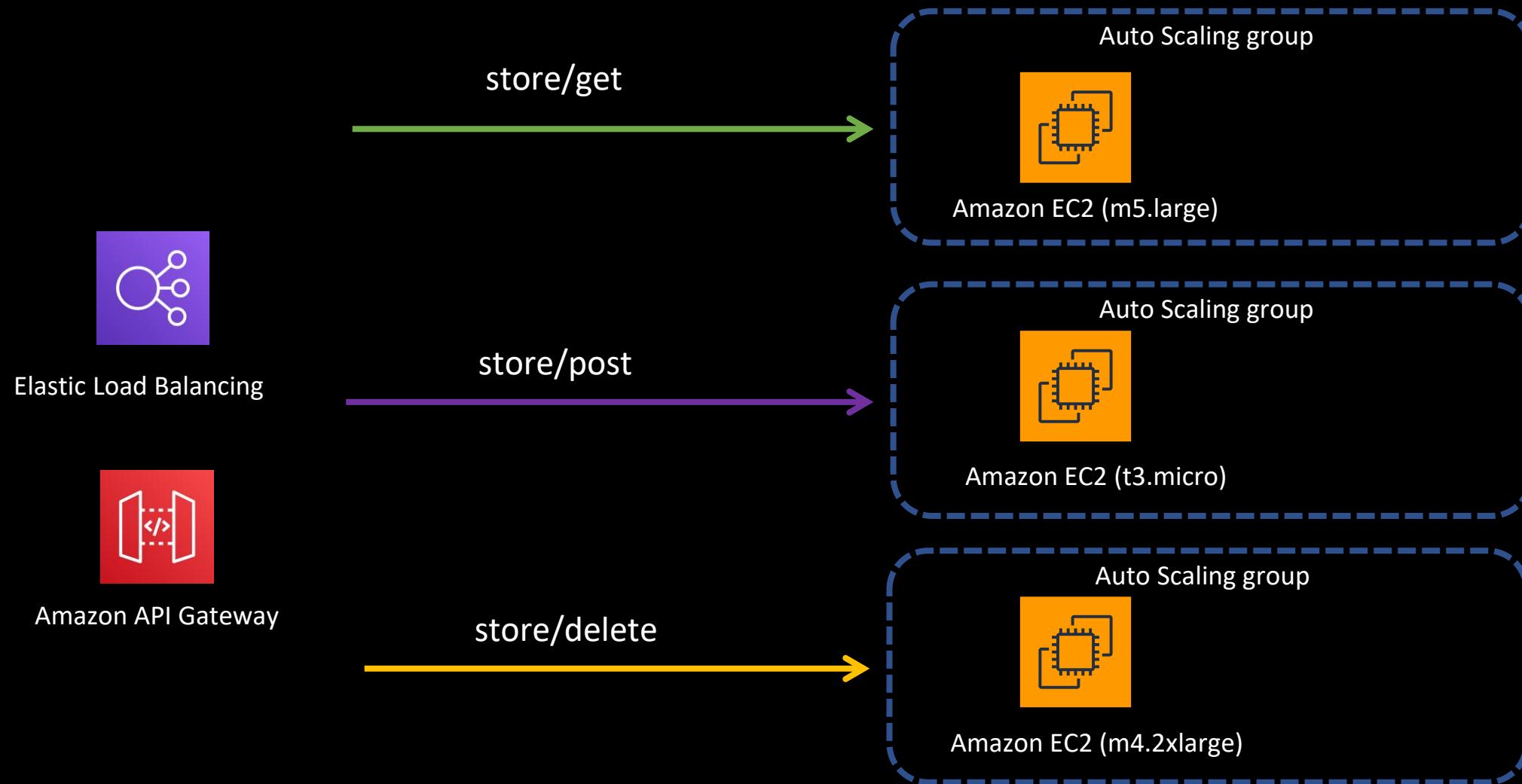
Deploying microservices in AWS

The answer to everything!



Amazon EC2



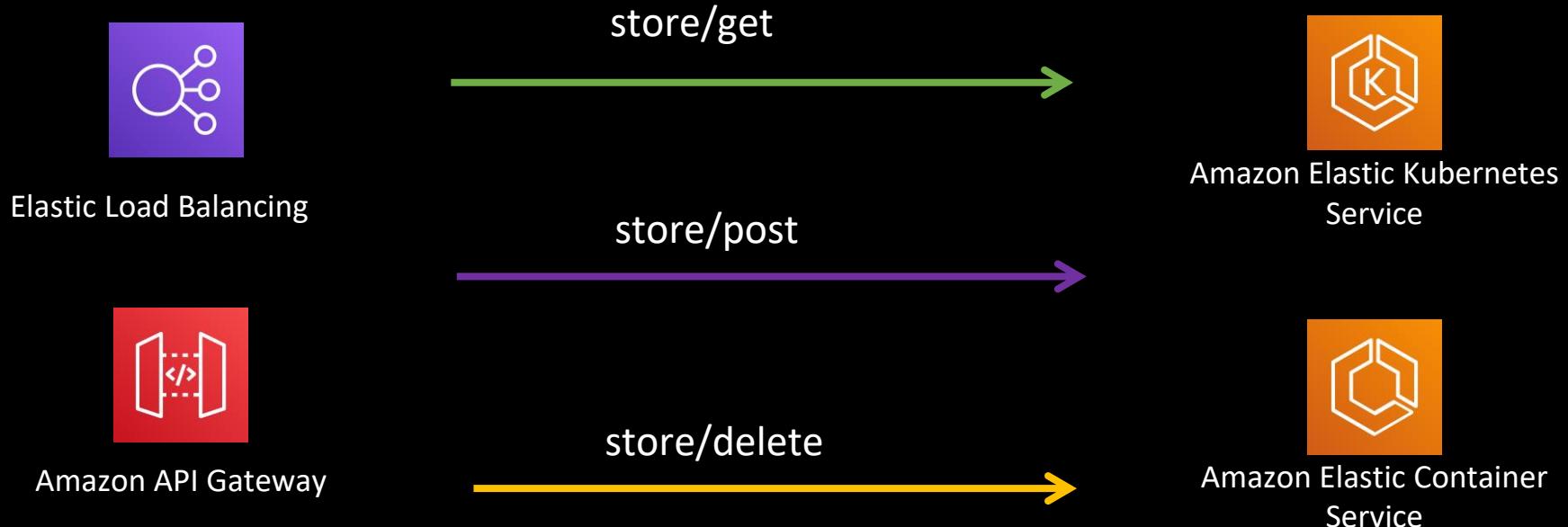


Serverless



Lambda scales automatically

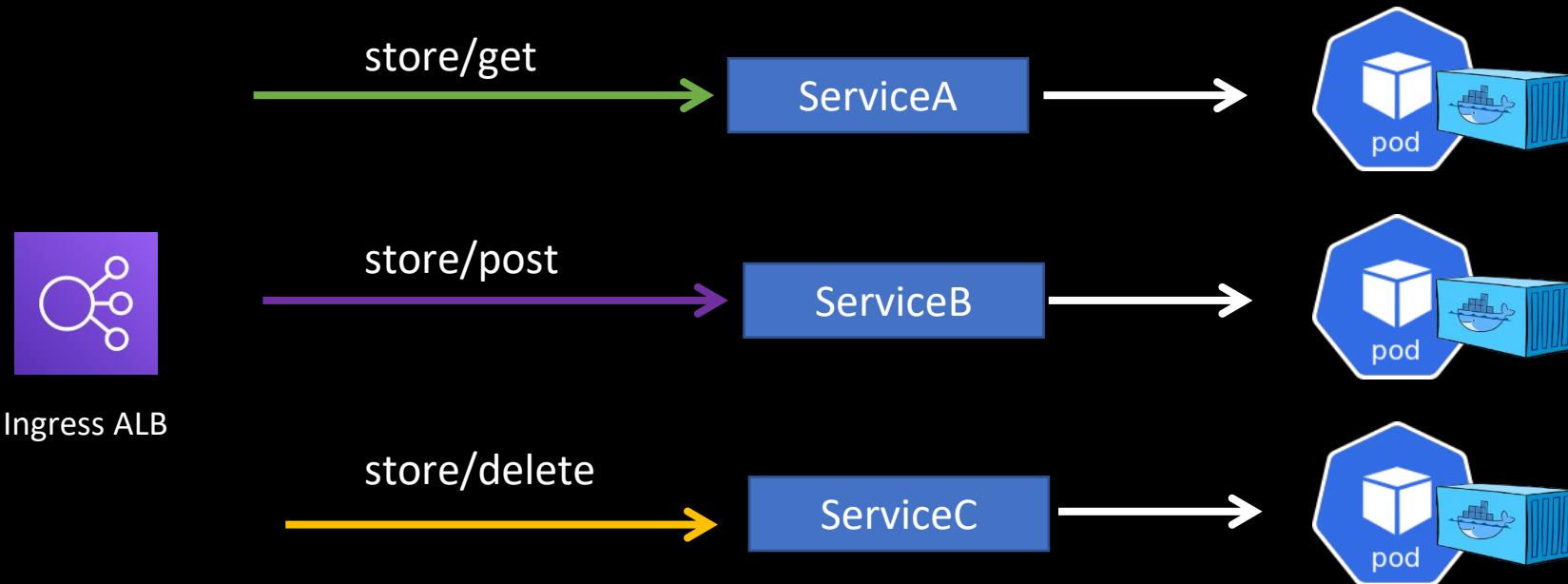
Container



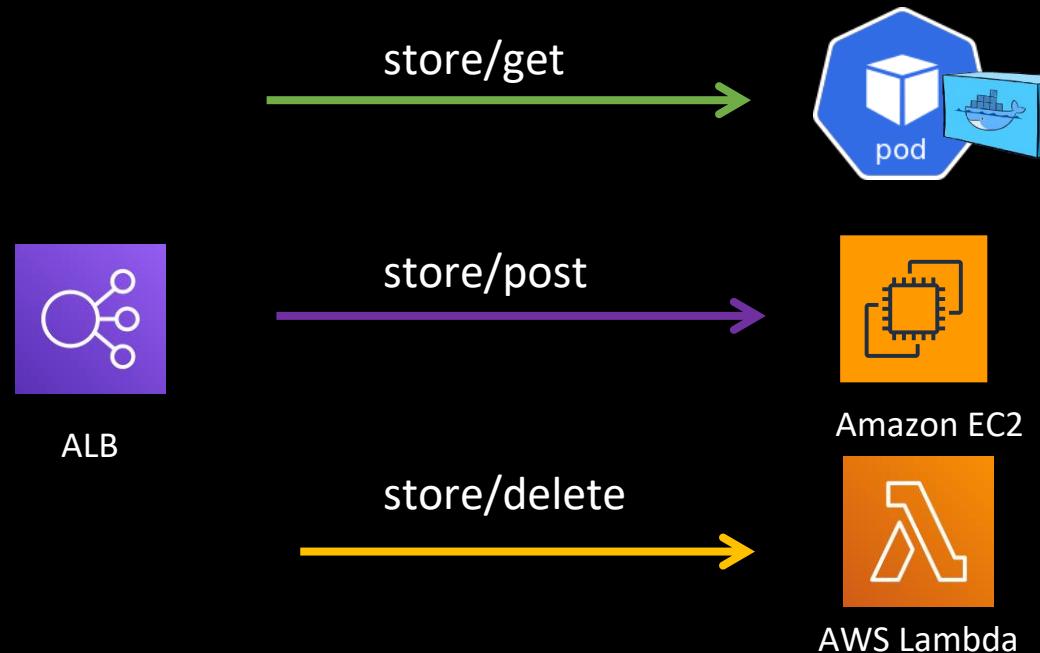
Kubernetes



Amazon Elastic Kubernetes
Service



Mix and Match!

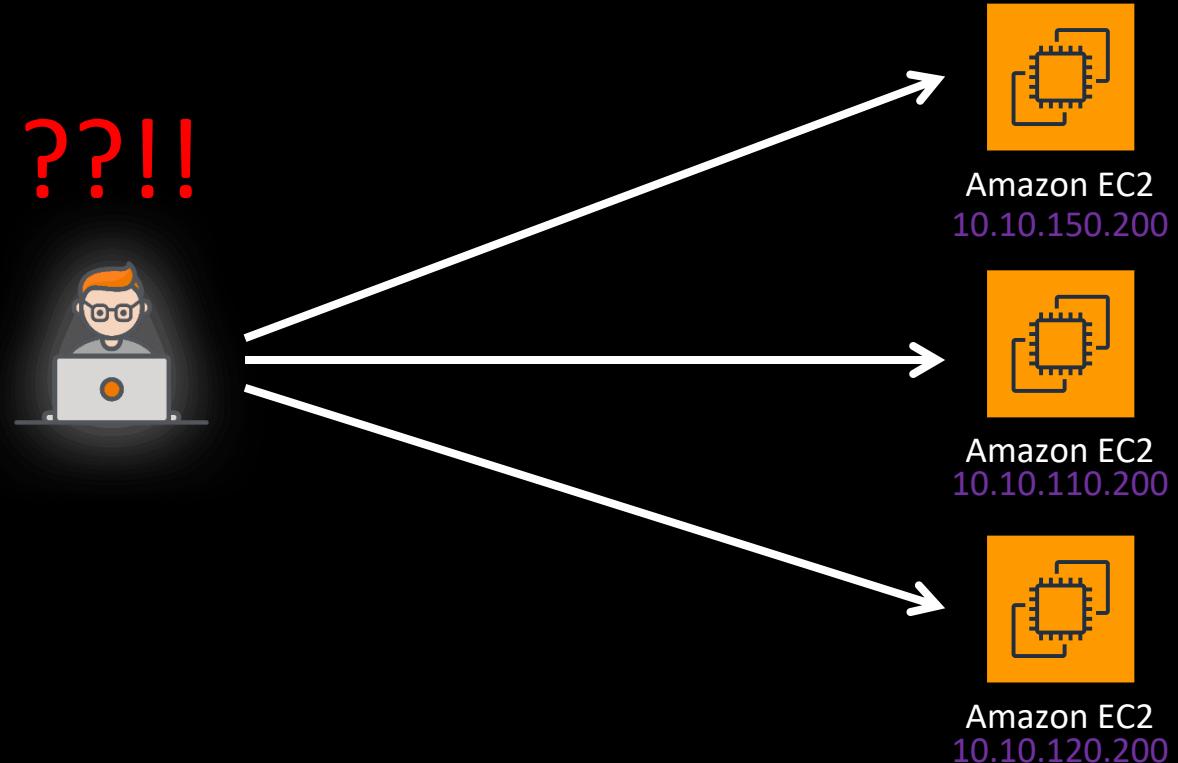


Load Balancer

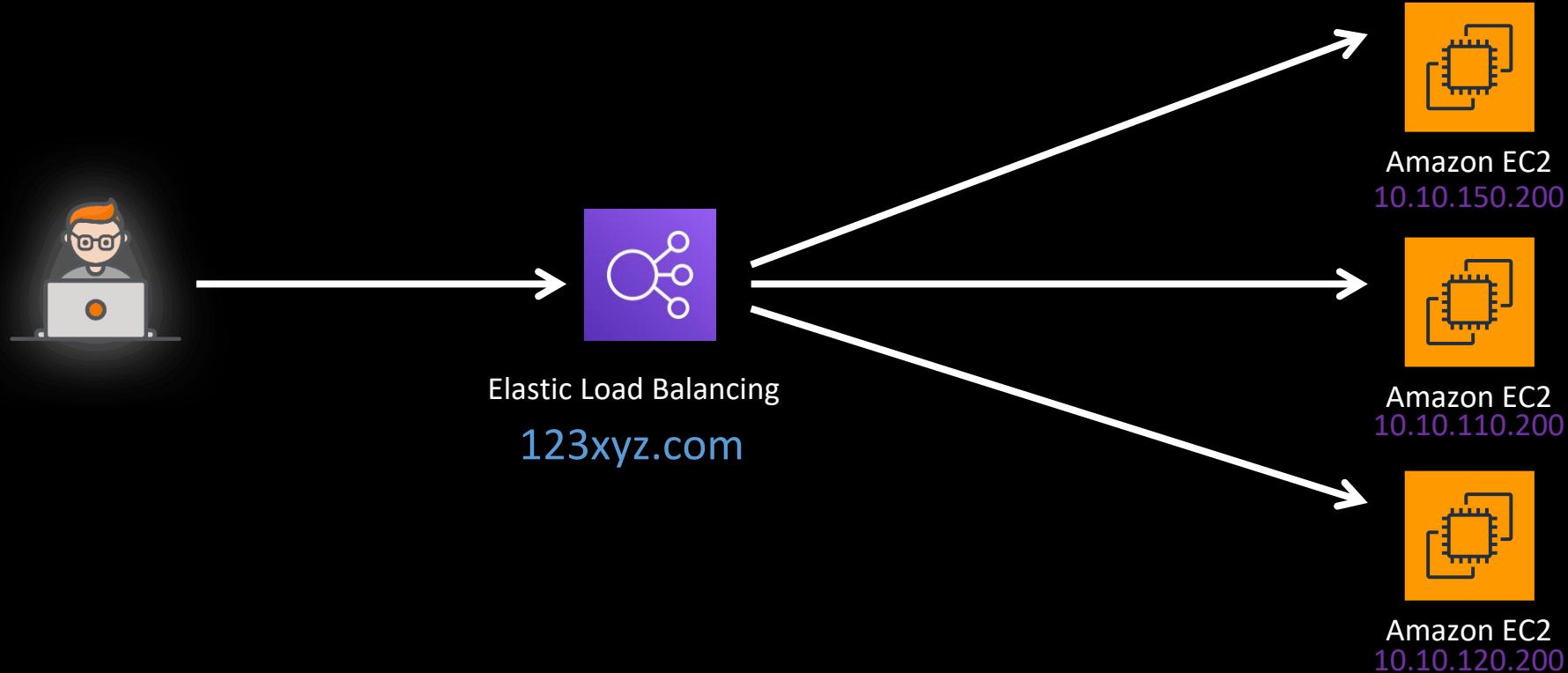
Your Application



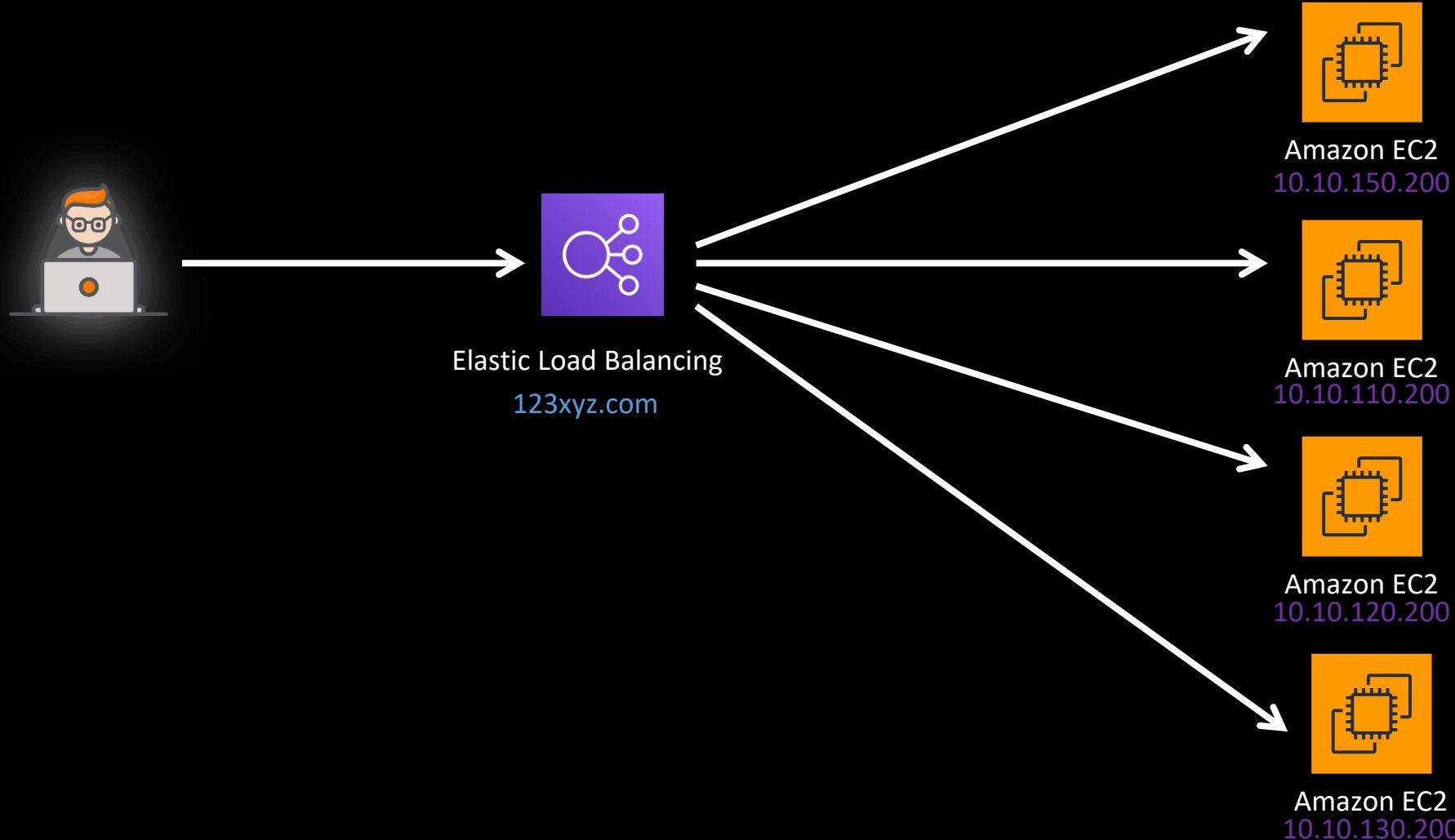
Your Application



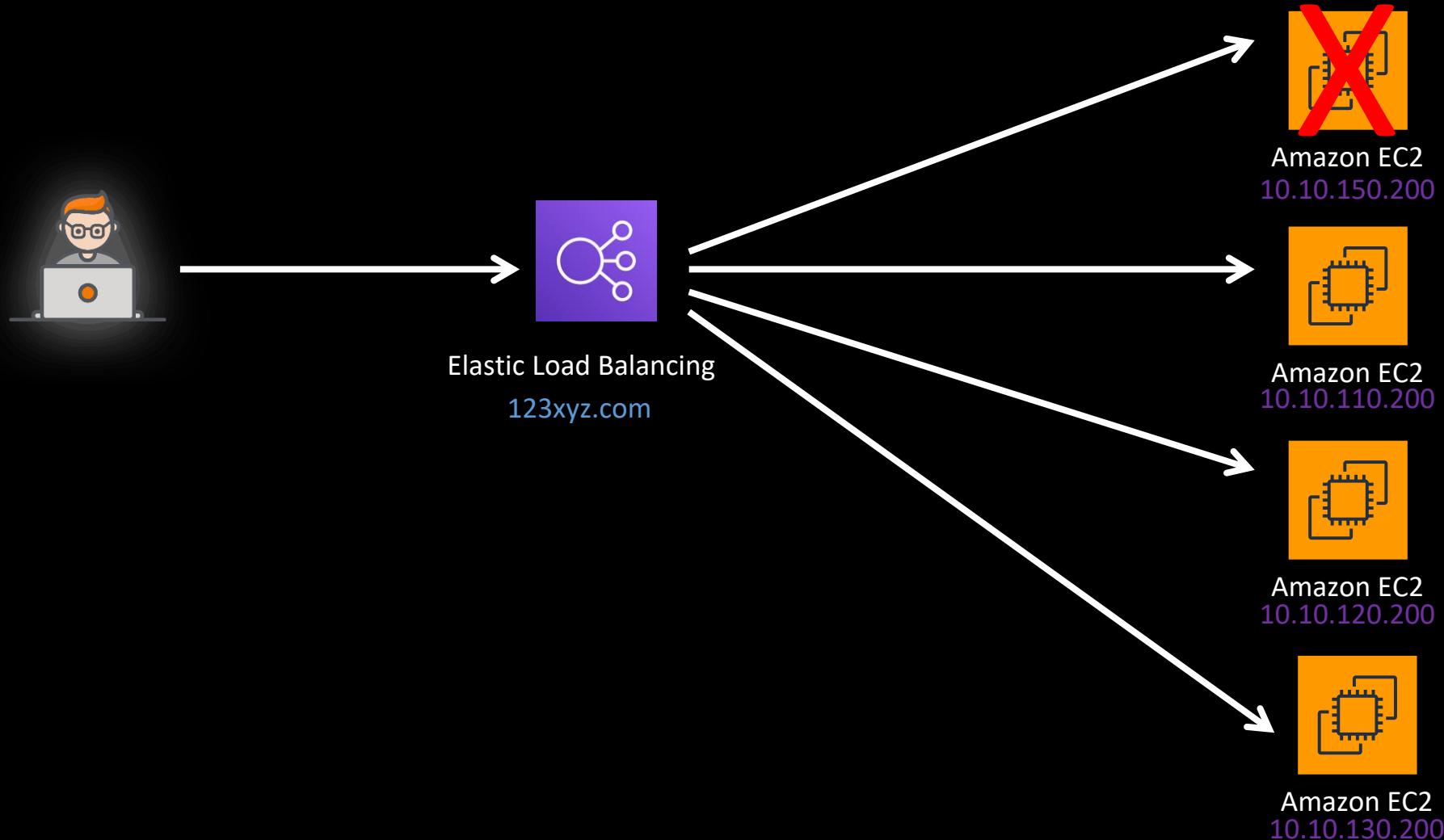
Your Application



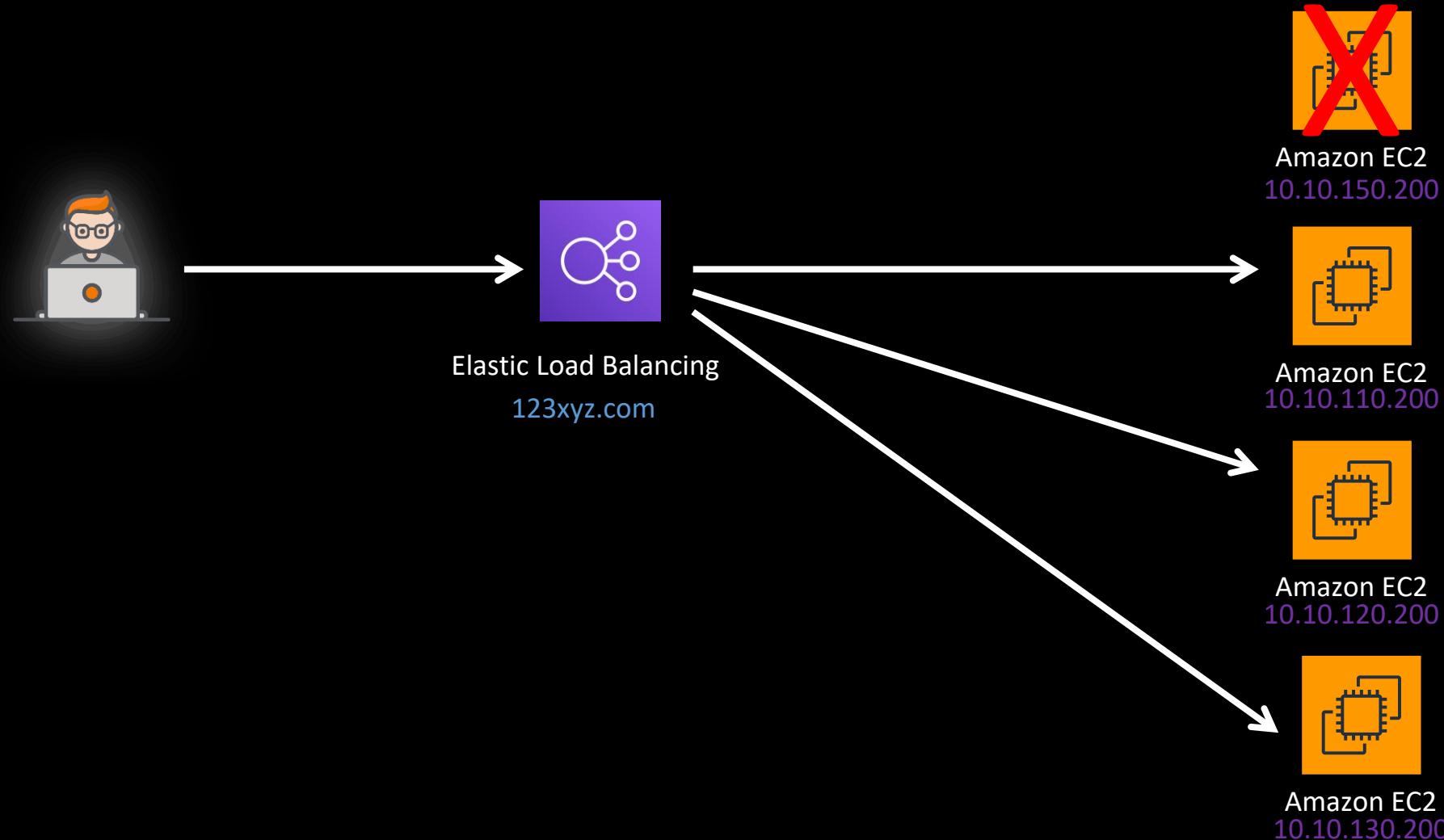
Your Application



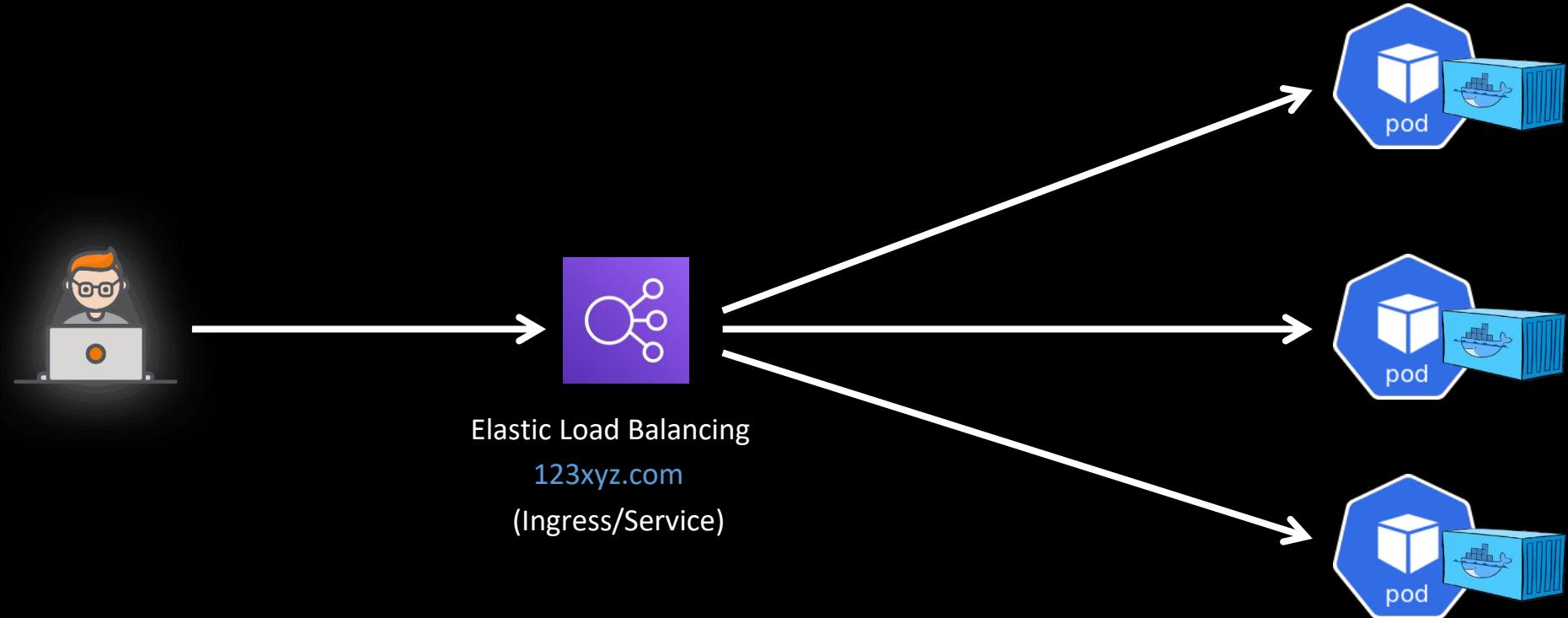
Your Application



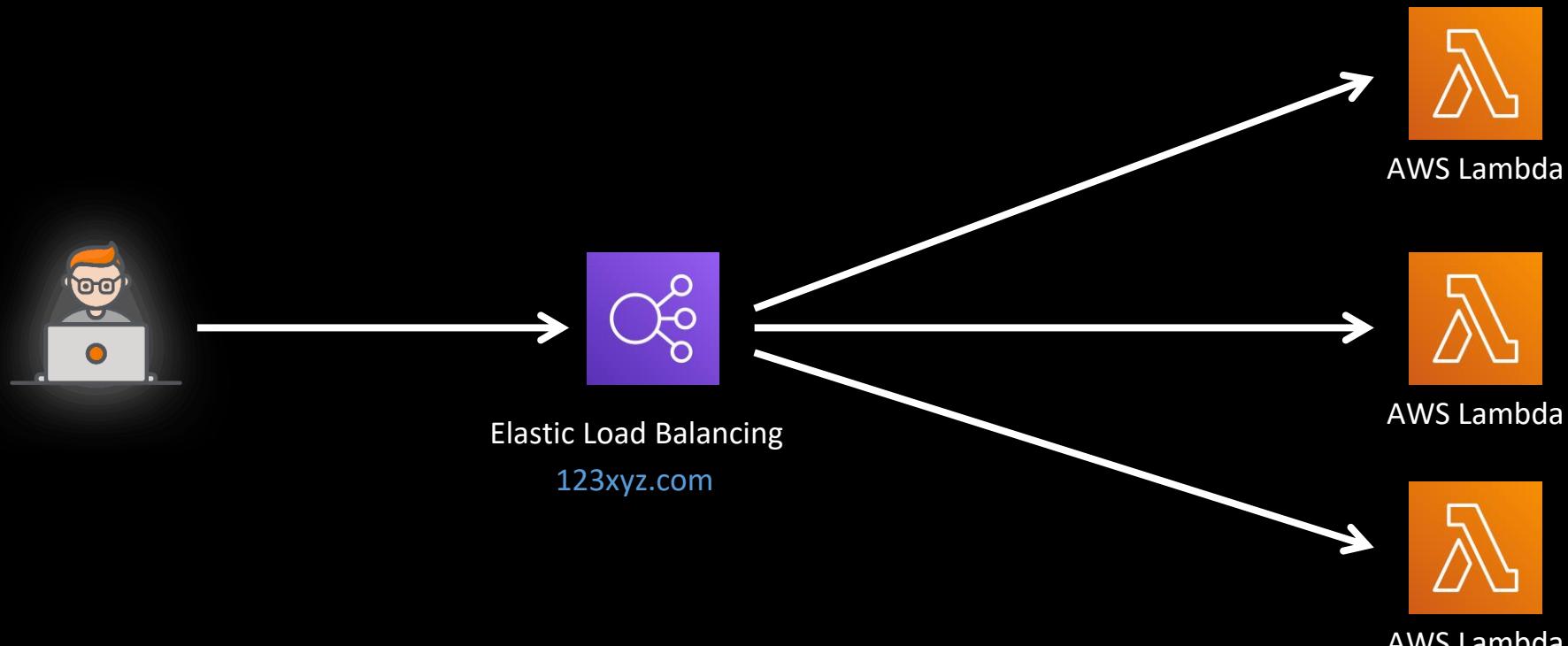
Your Application



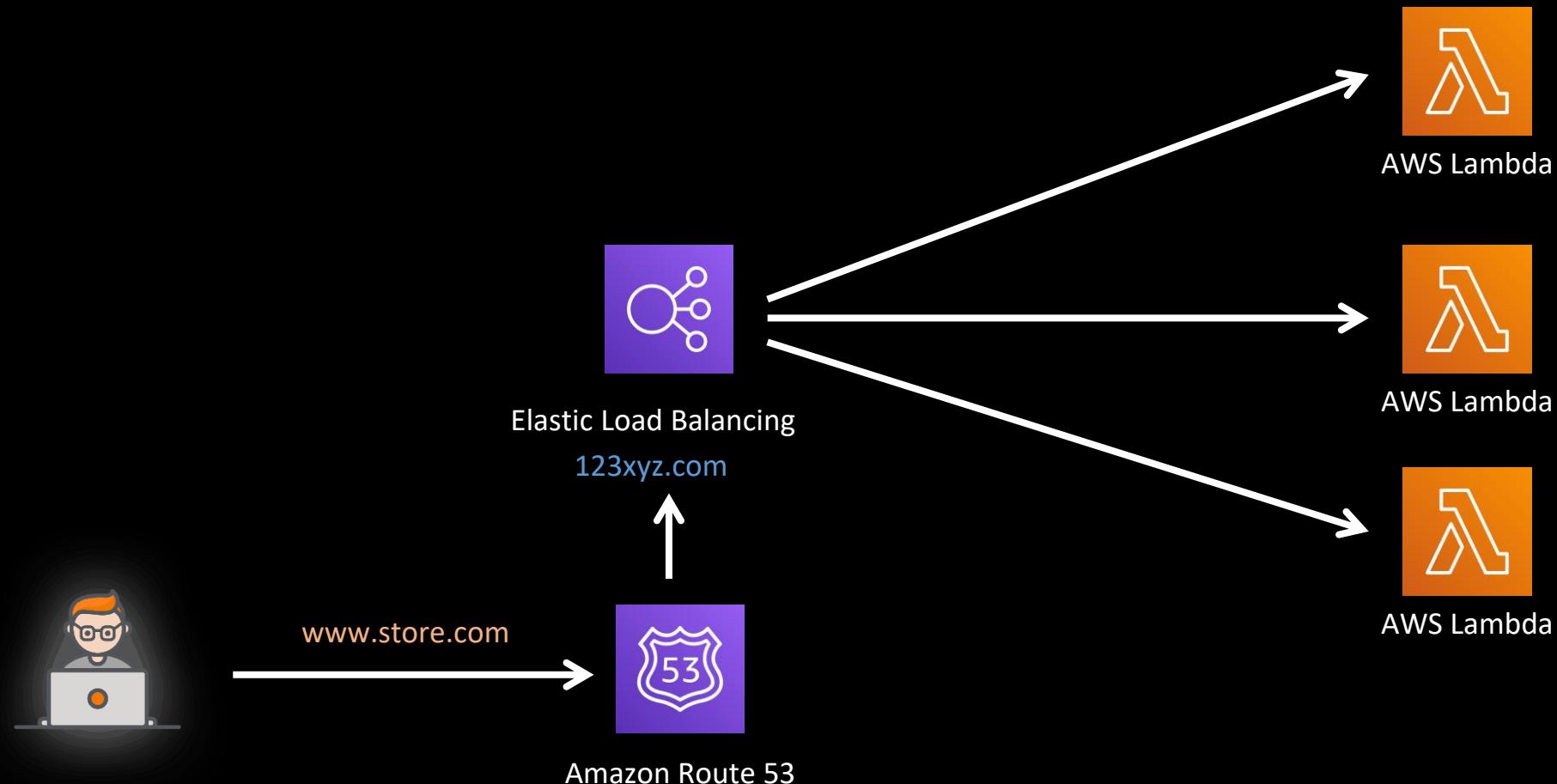
Your Application



Your Application



Your Application



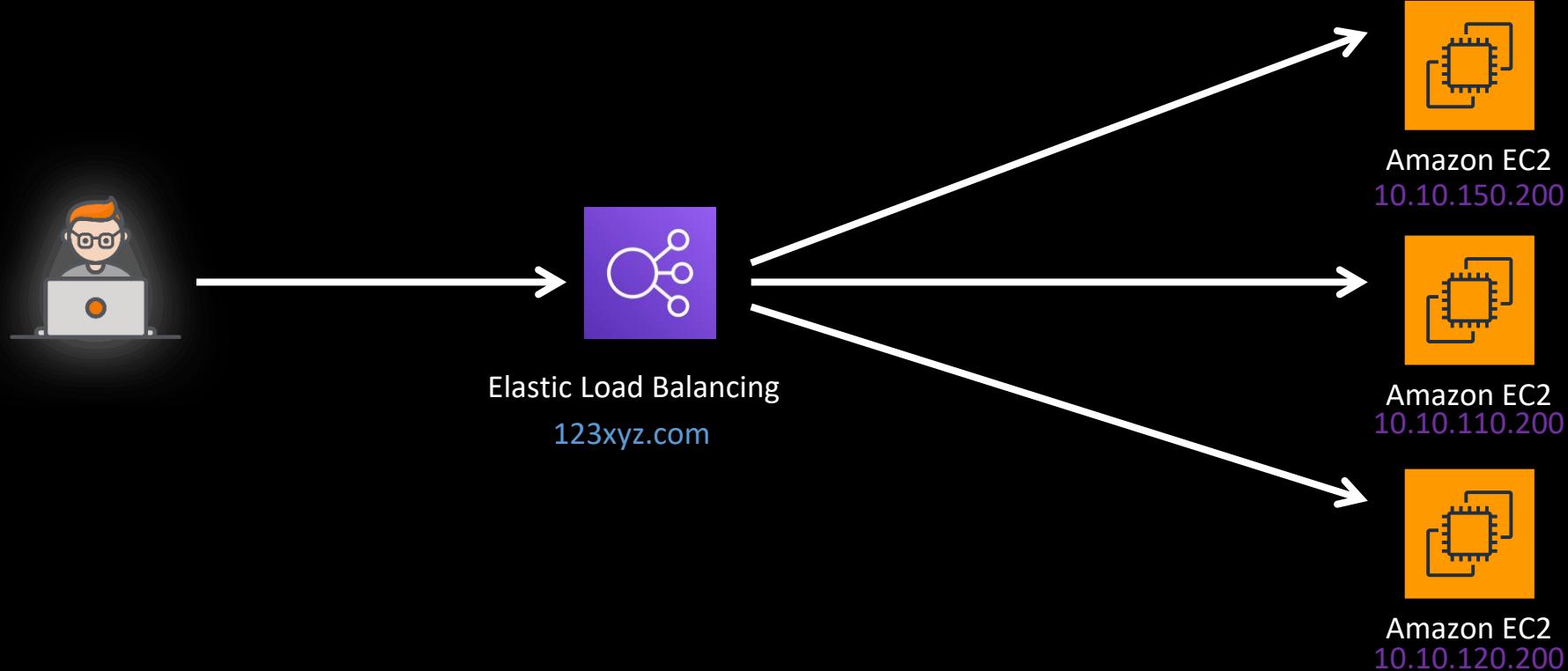
Load Balancer

- Automatically distributes incoming traffic across multiple targets
- Monitors health of targets
- Integrates with SSL
- “Elastic”

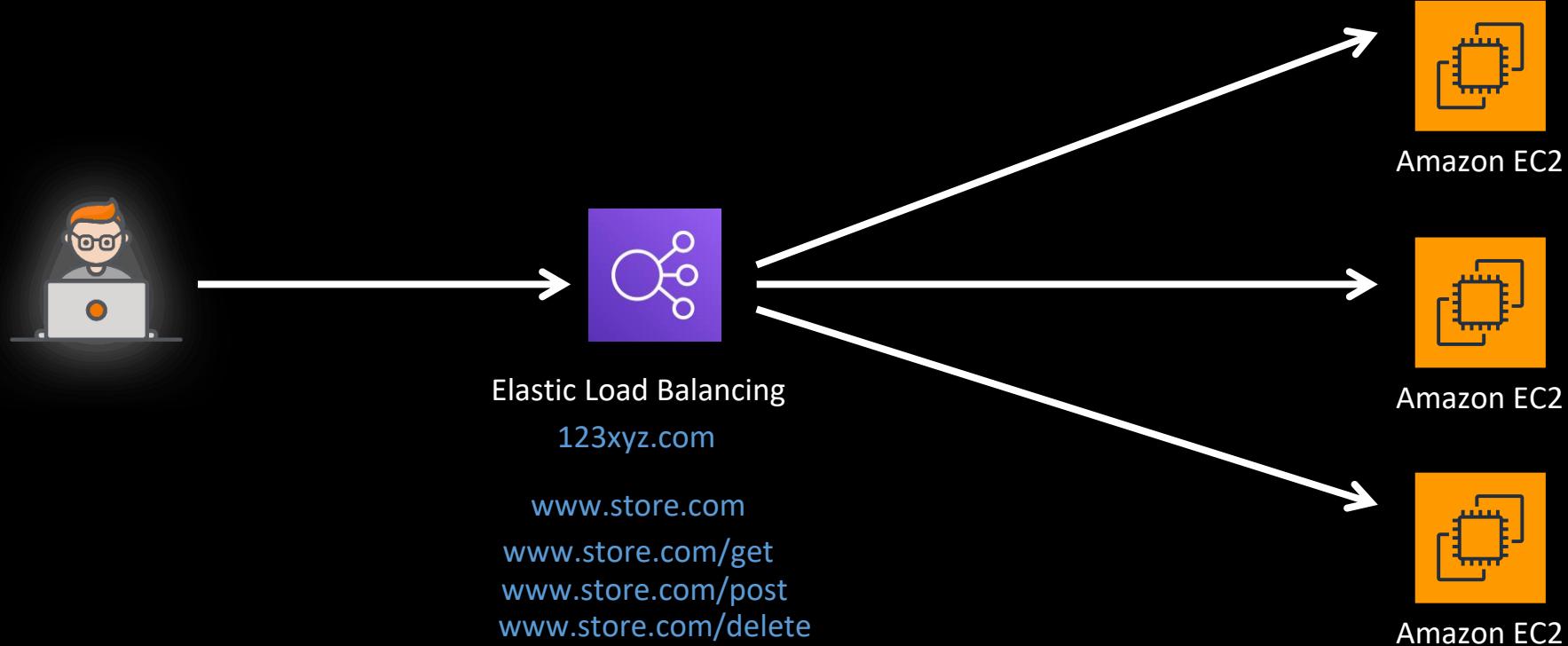
Types of Load Balancer

- Application Load Balancer
- Network Load Balancer

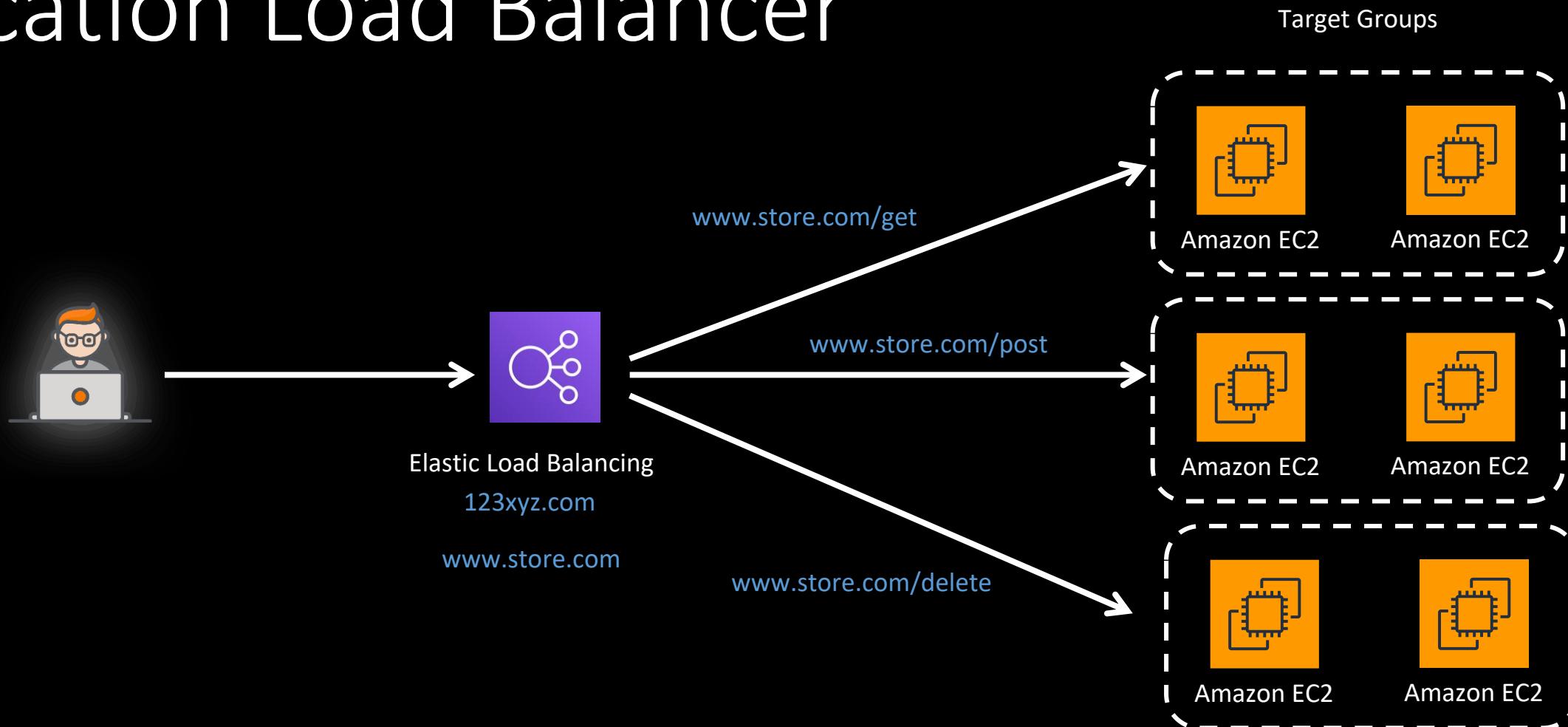
Application Load Balancer



Application Load Balancer



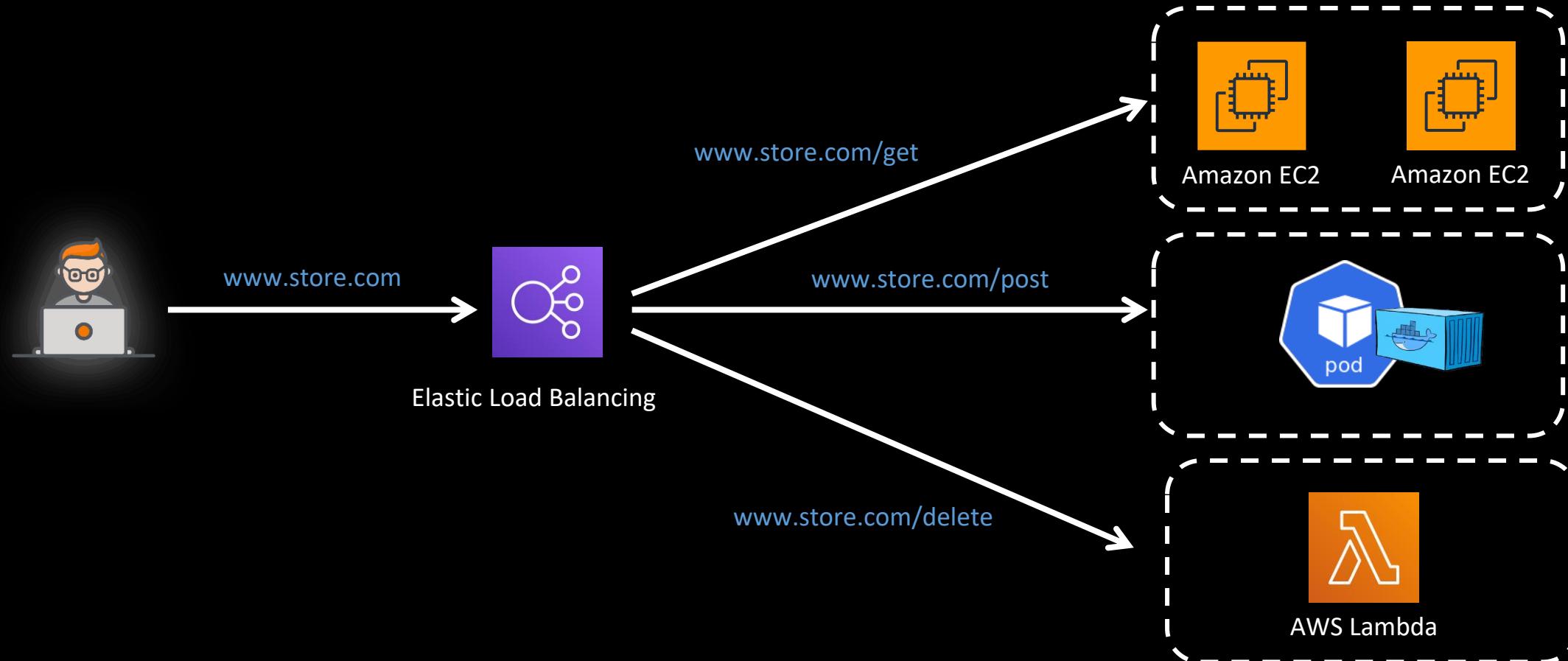
Application Load Balancer



Application Load Balancer

- Operates on OSI Layer 7
- Routes traffic based on url path
- Validates and terminates SSL
- Sticky session

Application Load Balancer



Network Load Balancer

- Operates on OSI Layer 4
- Routes traffic based on protocol and port of incoming traffic
- SSL passthrough

ALB or NLB?

- NLB handles spiky traffic better
 - ALB handles consistent high traffic better
- NLB exposes static IP address
 - ALB needs Global Accelerator
- Influenced by choices
 - API Gateway REST API Private integration with NLB with Private Link
 - NLB supports EC2 instance and IP address as backend target group
 - ALB supports EC2, IP address, and Lambda

API – What and Why?

Wiki Definition

An **application programming interface (API)** is a connection between [computers](#) or between [computer programs](#). It is a type of software interface, offering a service to other pieces of [software](#).^[1] A document or standard that describes how to build or use such a connection or interface is called an *API specification*. A computer system that meets this standard is said to *implement* or *expose* an API. The term API may refer either to the specification or to the implementation.

Real World Example



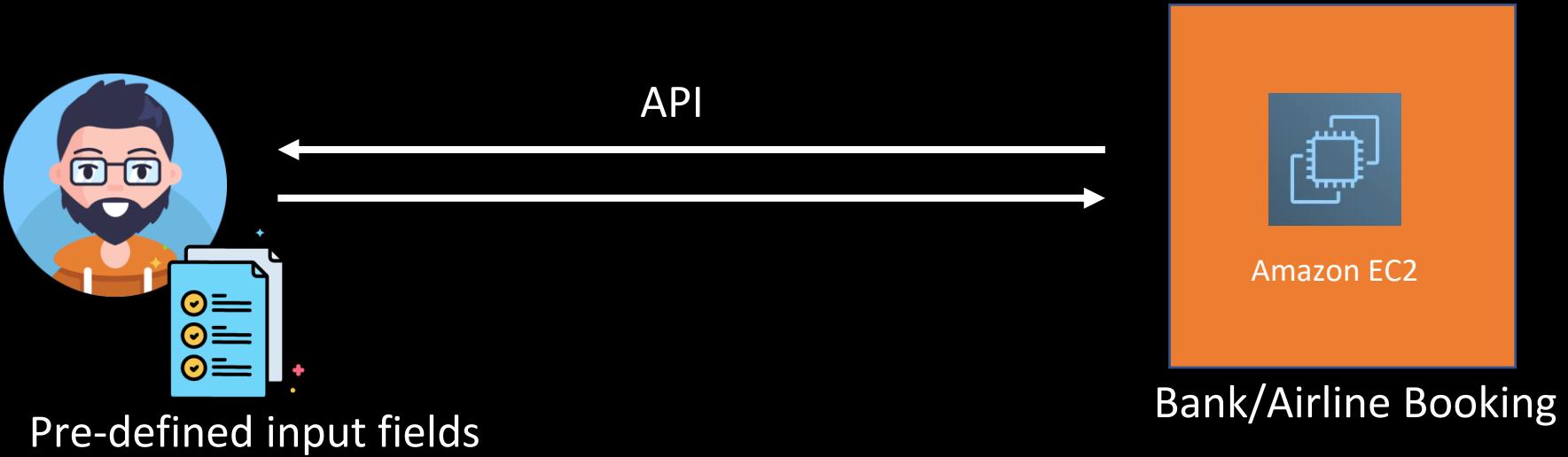
Real World Example



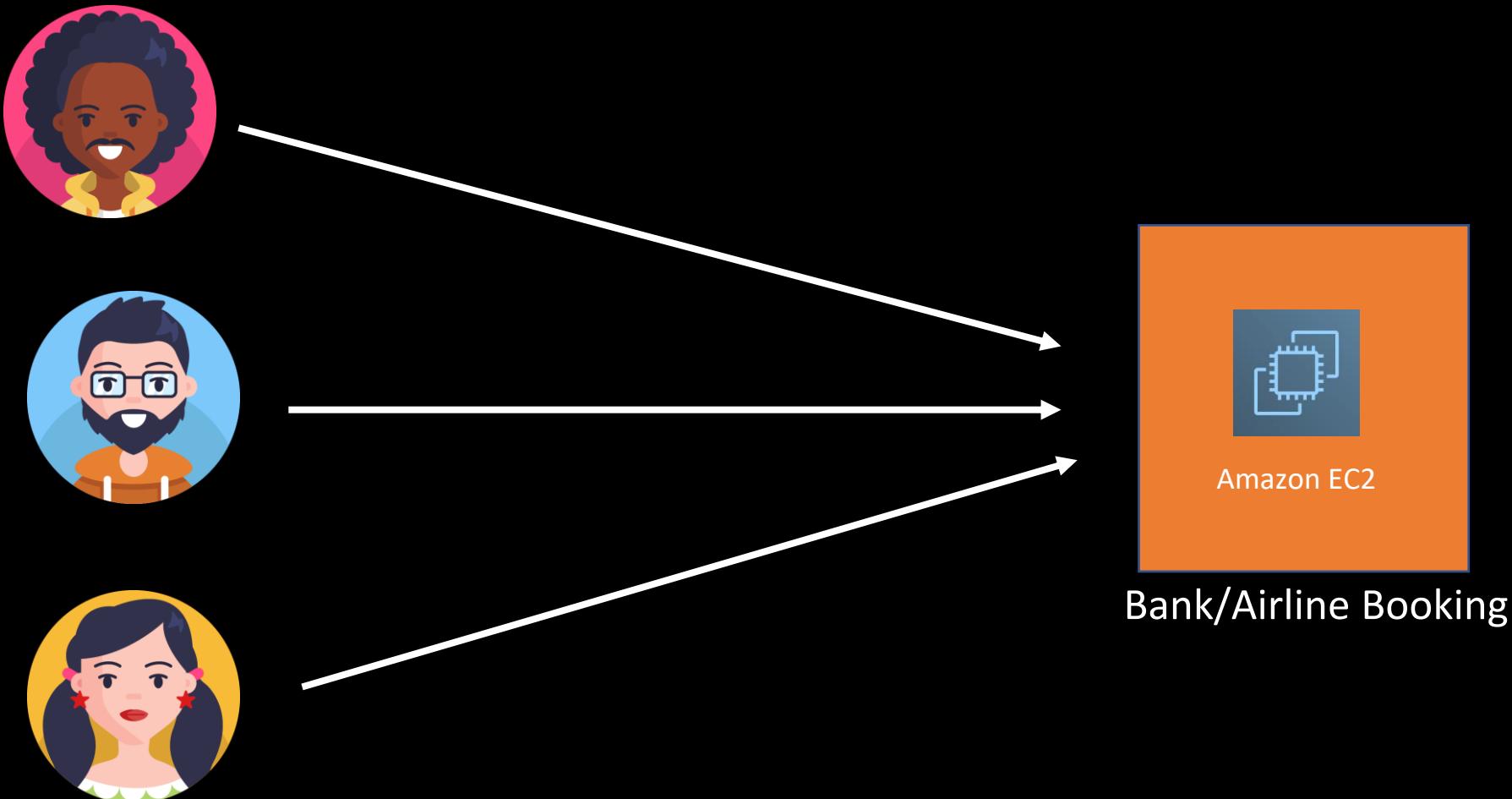
Real World Example



Back to IT



But Why?

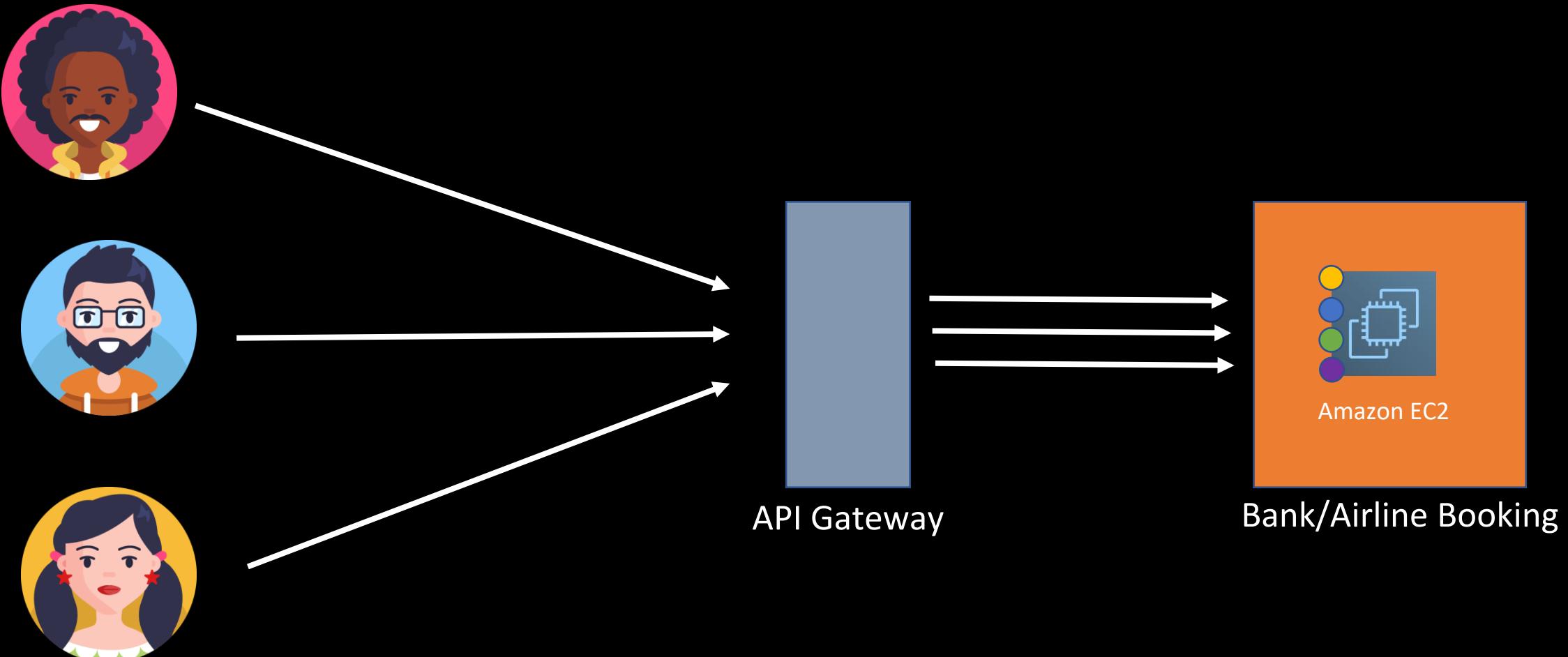


But Why?

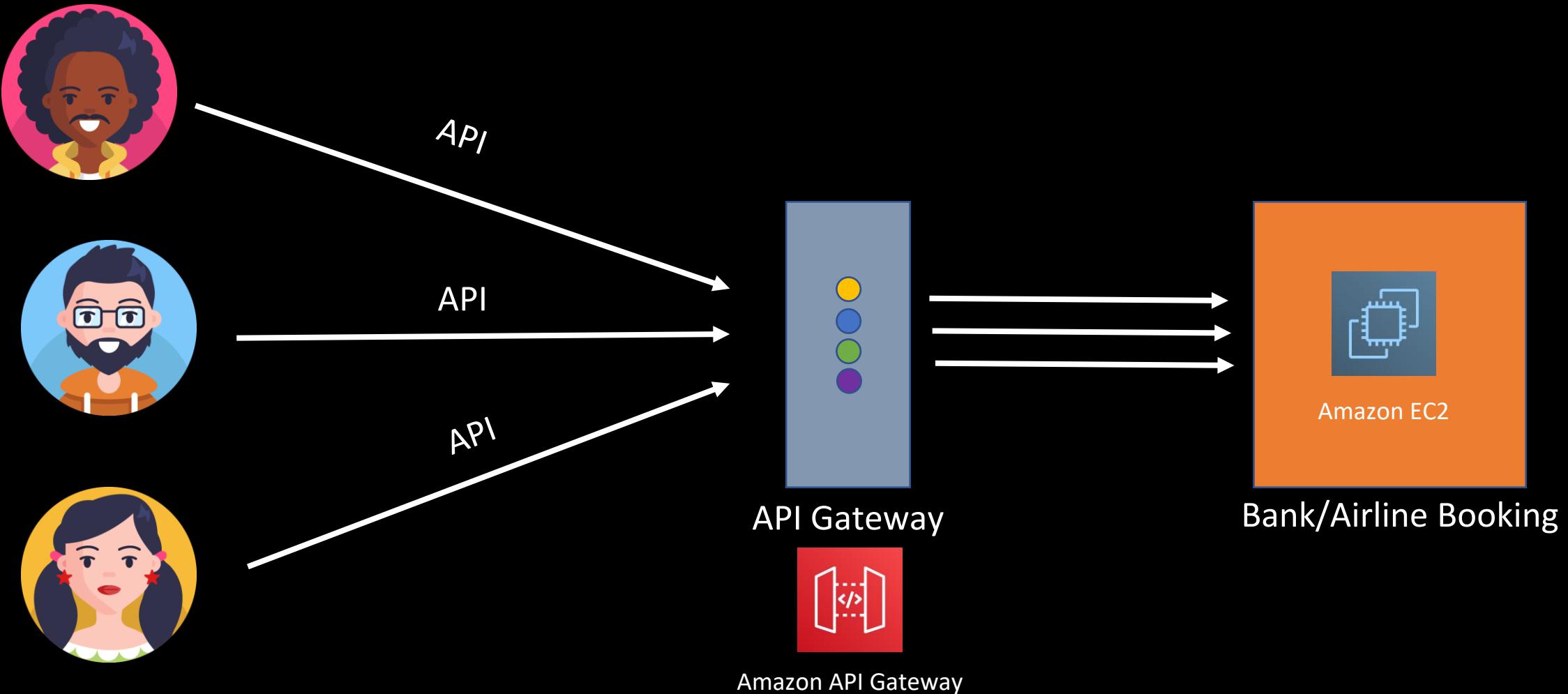


- Traffic management
- Load balancing
- Specific input/output needs
- AuthN/Z

But Why?



AWS Implementation

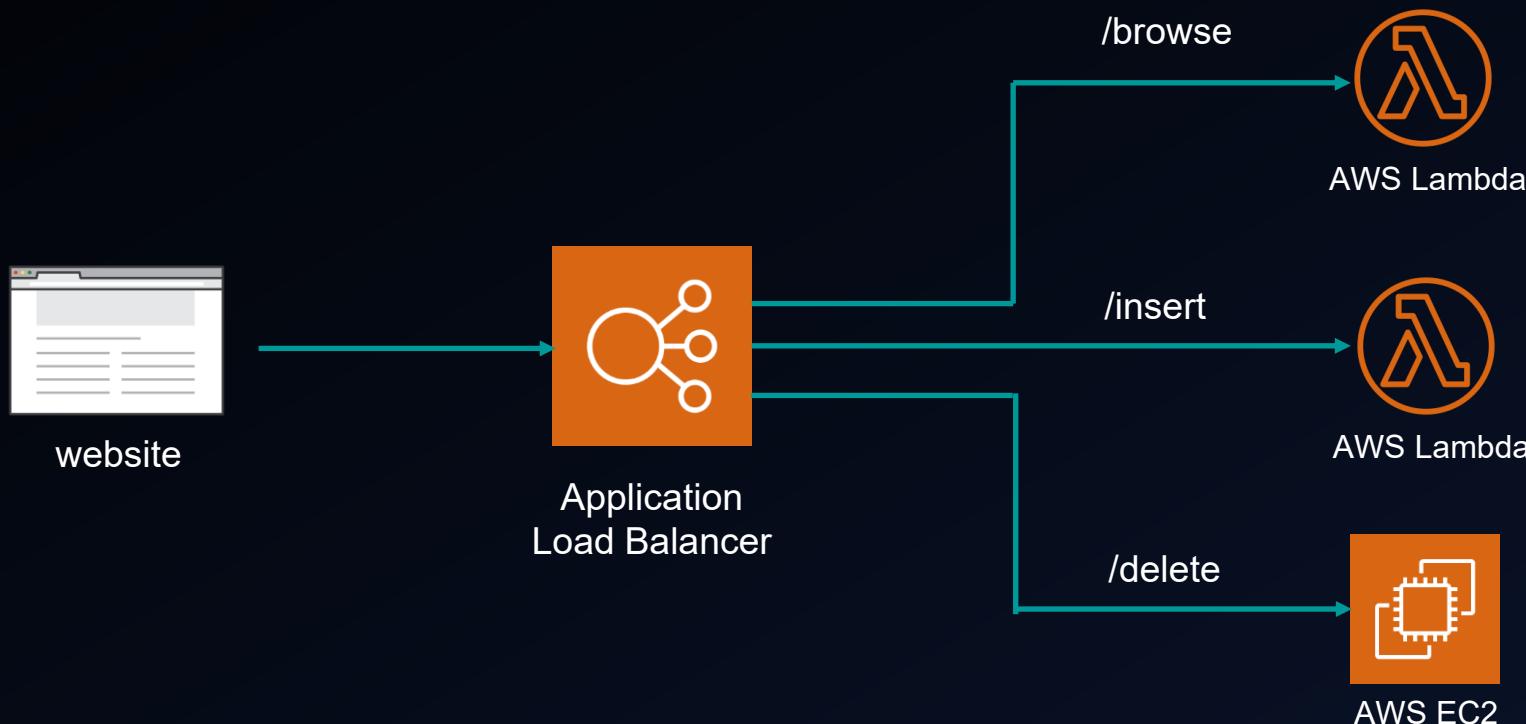


ALB vs. API Gateway

Application Load Balancer (ALB)

- Automatically distributes incoming traffic across backend targets
- Layer 7 load balancer
- Infrastructure managed by AWS, highly available, elastic

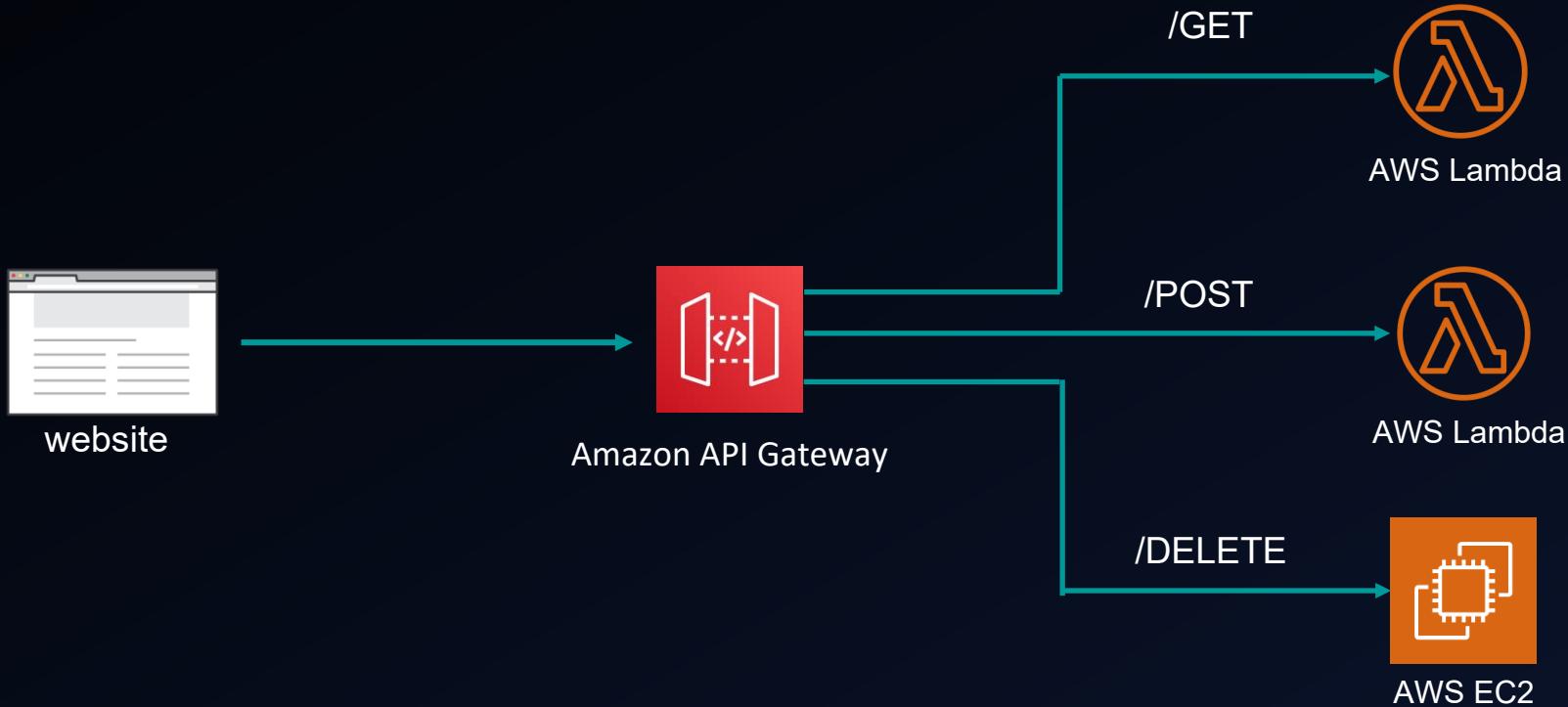
ALB Integration



API Gateway

- Fully managed and serverless API service from AWS
- Automatically scales up and down
- Infrastructure managed by AWS, highly available, elastic

API Gateway Integration



API Gateway



Can implement rate limiting, bursting for APIs

Integrate with AWS WAF for protection

Not possible to get a static IP address for endpoint

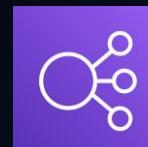
Accepts HTTPS traffic

Able to do request validation, request/response mapping

Able to handle spiky traffic (default rate – 10k rps, 5k burst rate)

Able to integrate with Lambda from different region, even different AWS account

ALB



No rate limiting, bursting capability

Integrate with AWS WAF for protection

Possible to get a static IP address for load balancer endpoint

Accepts HTTP, HTTPS traffic

Not able to do request validation, request/response mapping

Delay during spiky traffic, pre-allocate LCUs to avoid delay (charged extra)

ALB is a regional service

API Gateway



Able to export/import APIs cross API platforms using swagger, Open API Spec 3.0

Have extensive AuthN/Z integration – API Key, IAM, Cognito User Pool, Cognito Identity Pool, external IdP

Able to cache responses

Timeout limit 30 seconds

Integrates with almost all AWS services

No health check available

Pay per use

ALB



No direct method to import/export rules for cross platforms

Integration with any OIDC compliant IdP (Cognito, LDAP etc.)

Not able to cache responses

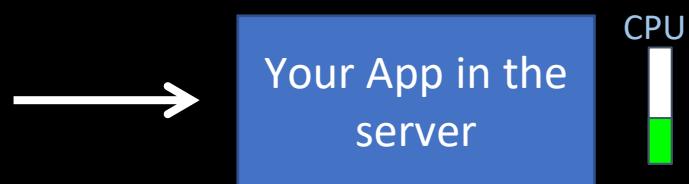
Timeout limit 4000 seconds

Use EC2, Lambda, IP addresses as backend
Health check available

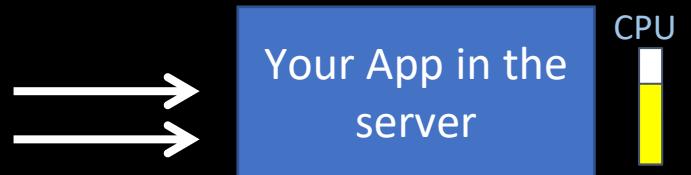
Pay for idle

Scaling – Vertical vs Horizontal

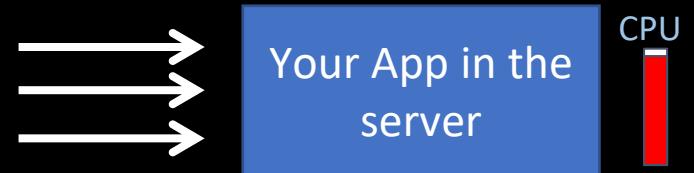
Regular Application



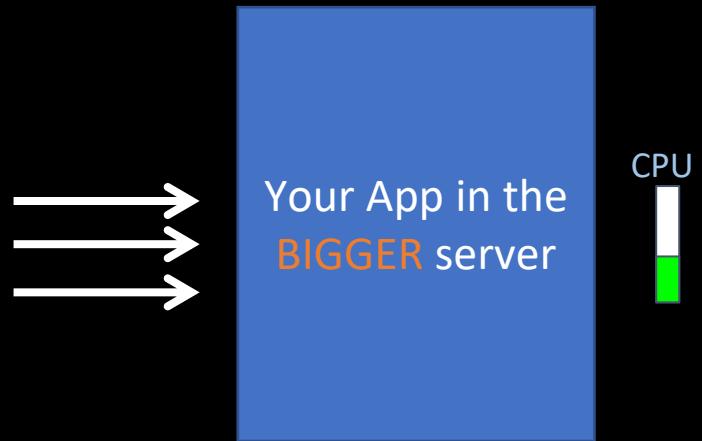
Regular Application



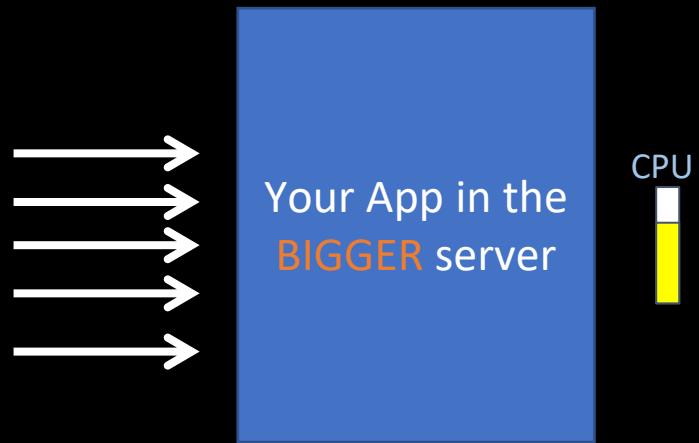
Regular Application



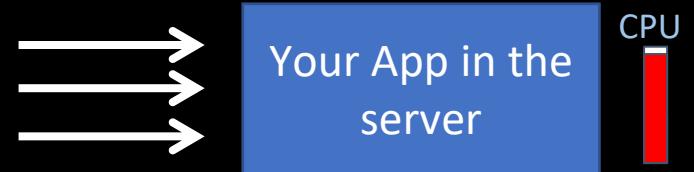
Vertical Scaling



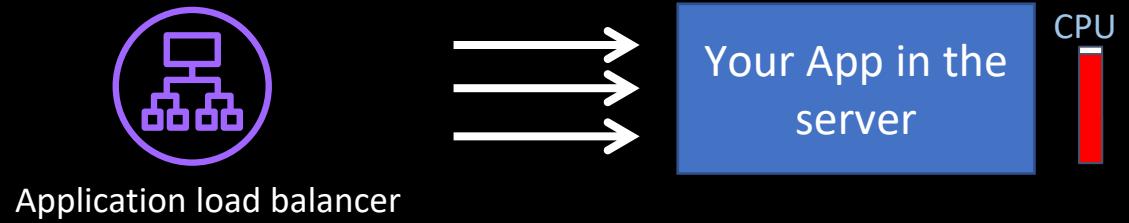
Vertical Scaling



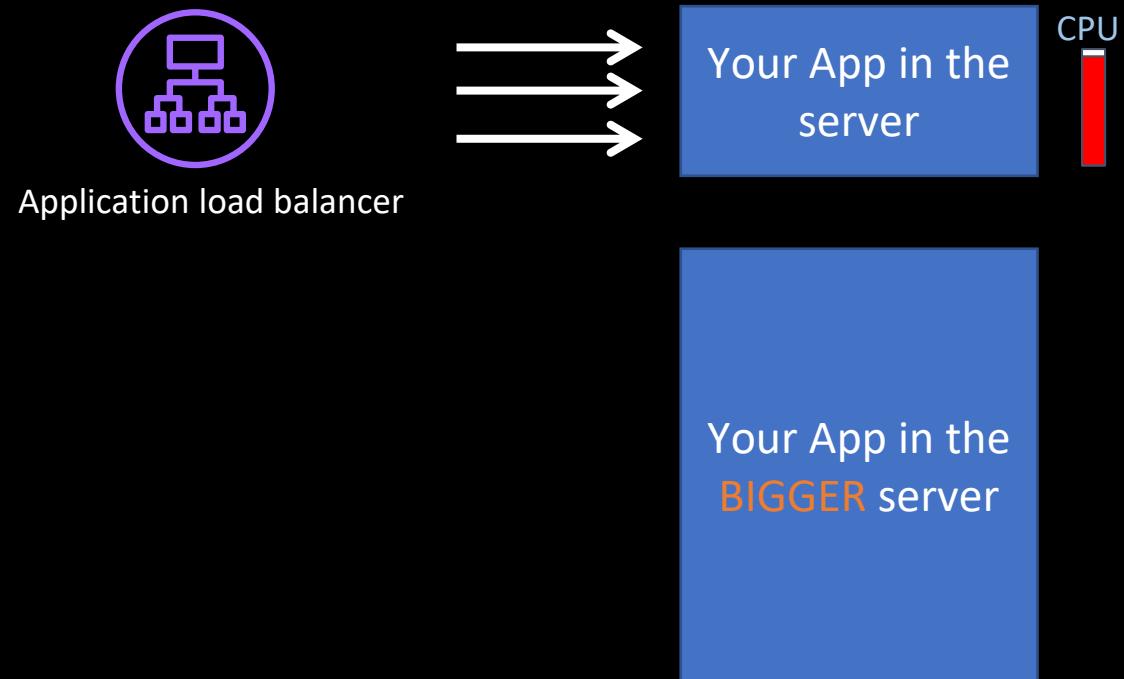
Vertical Scaling Deep Dive



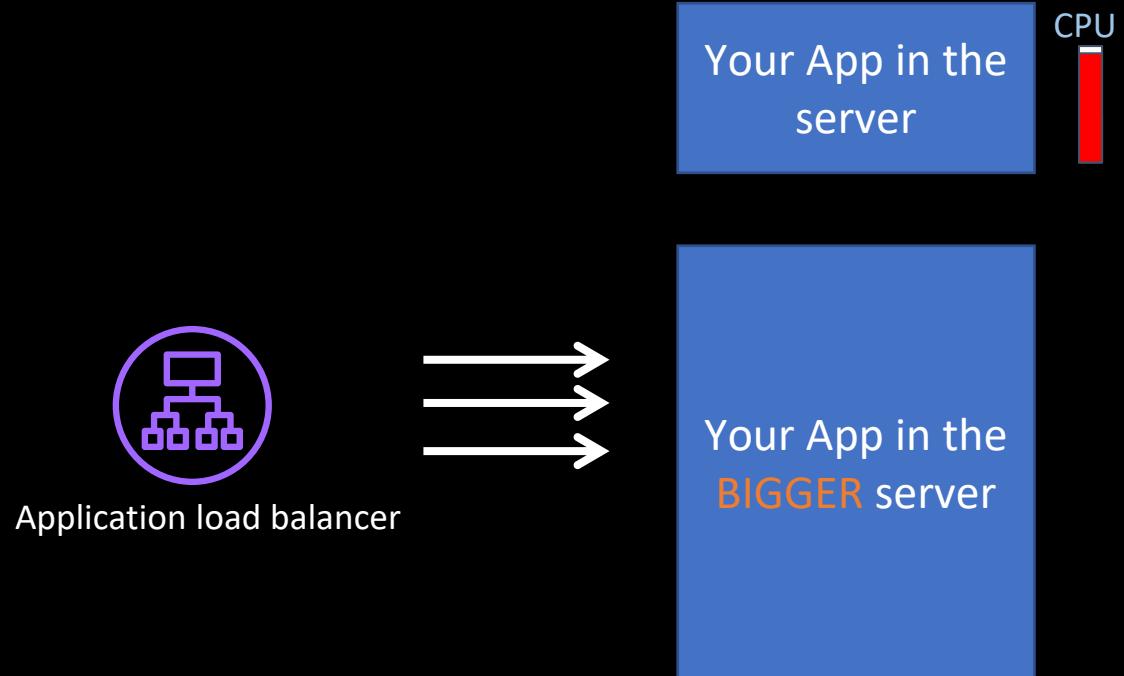
Vertical Scaling Deep Dive



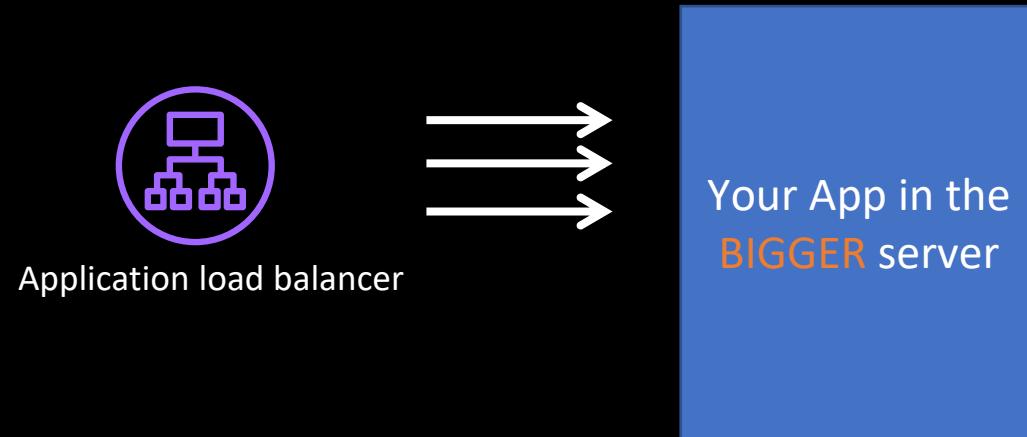
Vertical Scaling Deep Dive



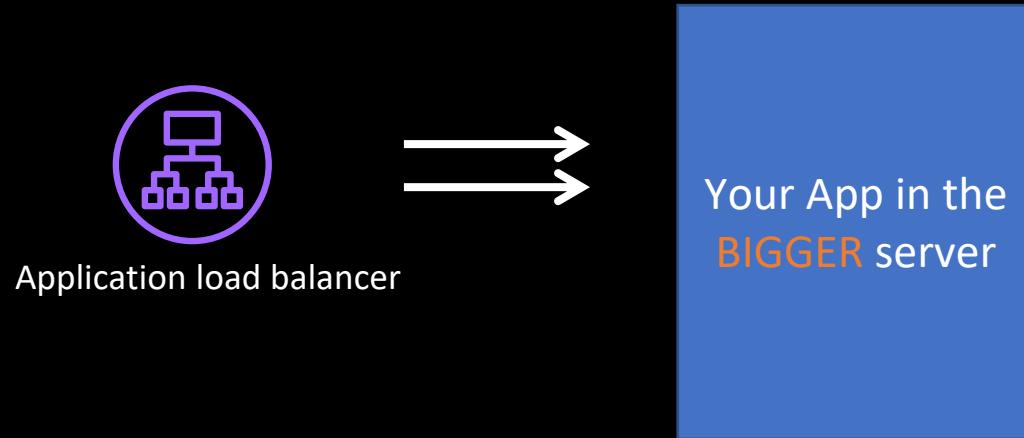
Vertical Scaling Deep Dive



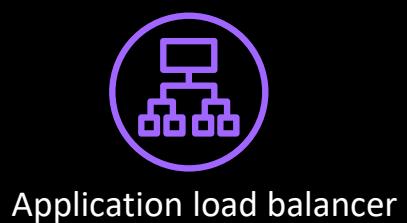
Vertical Scaling Deep Dive



Vertical Scaling Deep Dive

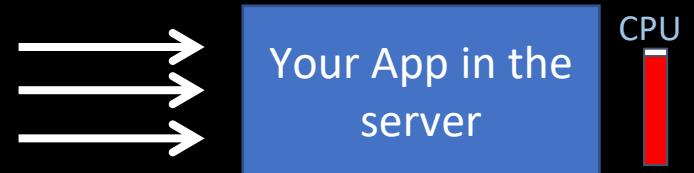


Vertical Scaling Challenges

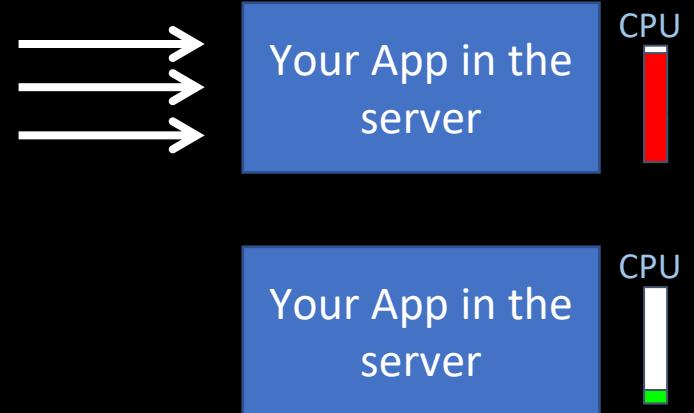


- Scaling up/down takes longer
- Chance of missing transactions during scaling cutover
- Limited scaling
- Expensive

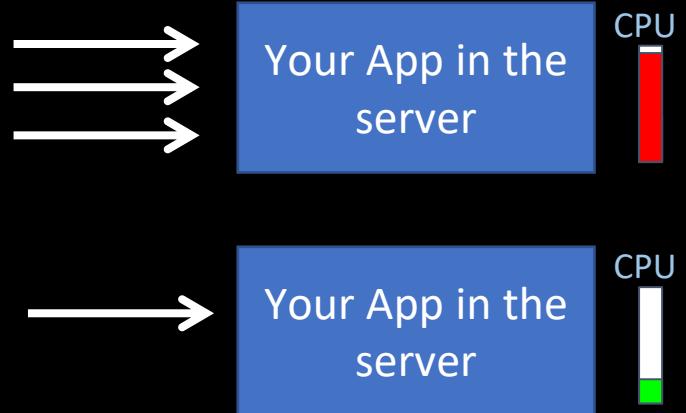
Regular Application



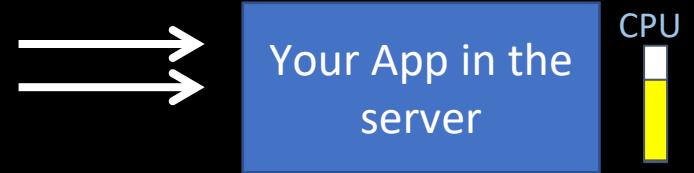
Horizontal Scaling



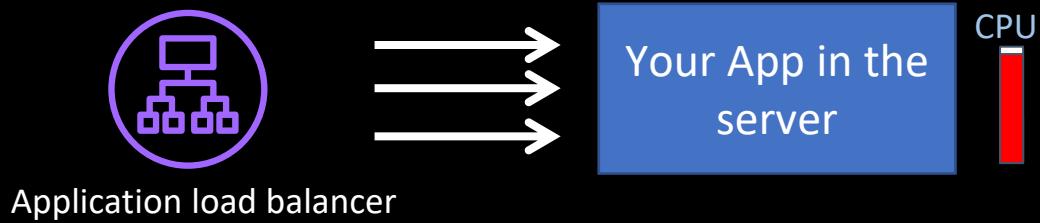
Horizontal Scaling



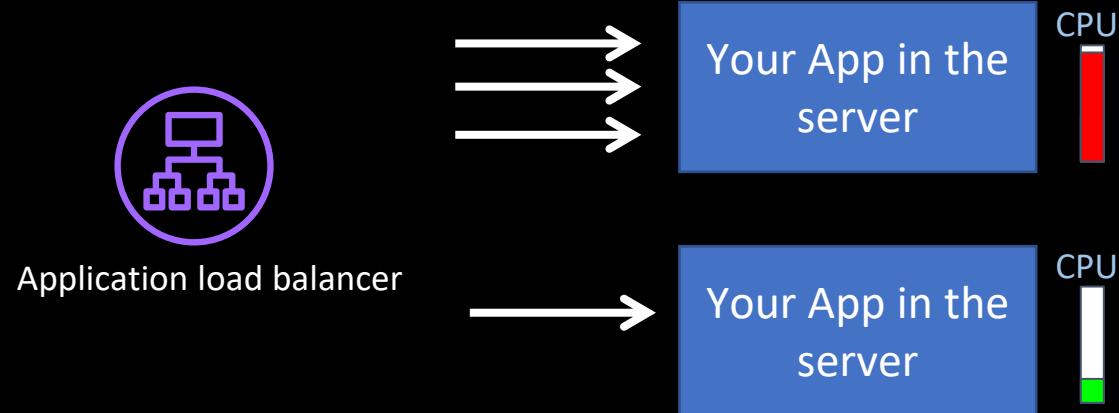
Horizontal Scaling



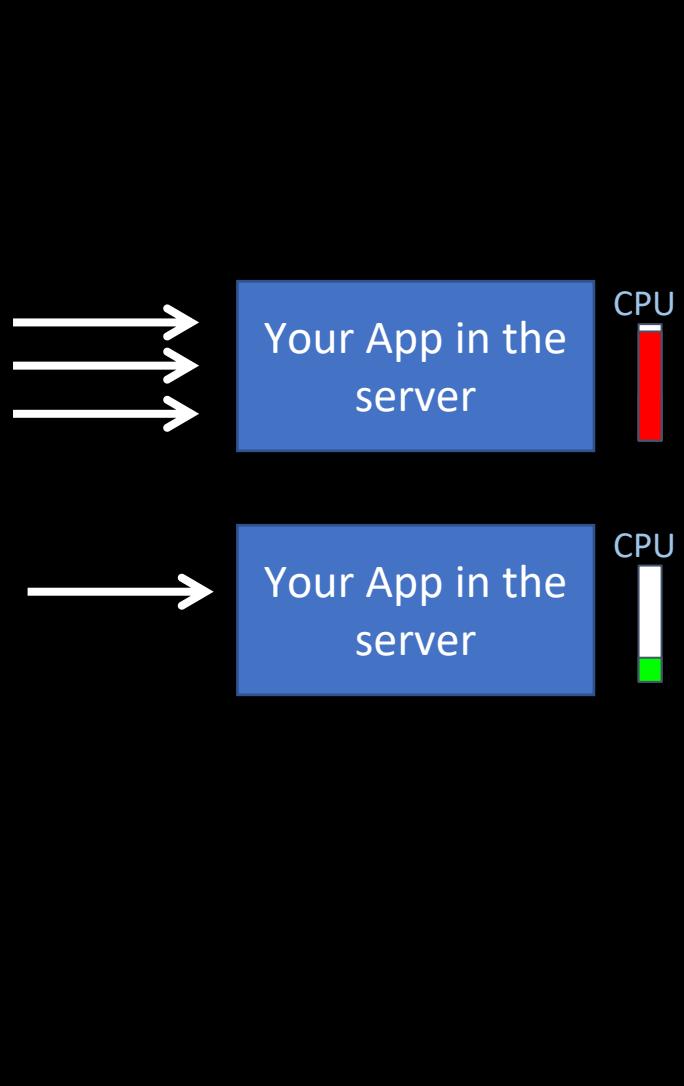
Horizontal Scaling Deep Dive



Horizontal Scaling Deep Dive



Horizontal Scaling



Application load balancer

- Scaling up/down faster
- Massively scalable
- Cost effective
- Legacy code needs to be refactored for horizontal scaling

VM, Container, Serverless Scaling on AWS

Vertical vs Horizontal Scaling on AWS

- EC2 vertical and horizontal scaling
- Container scaling
- Lambda scaling
- Fargate scaling

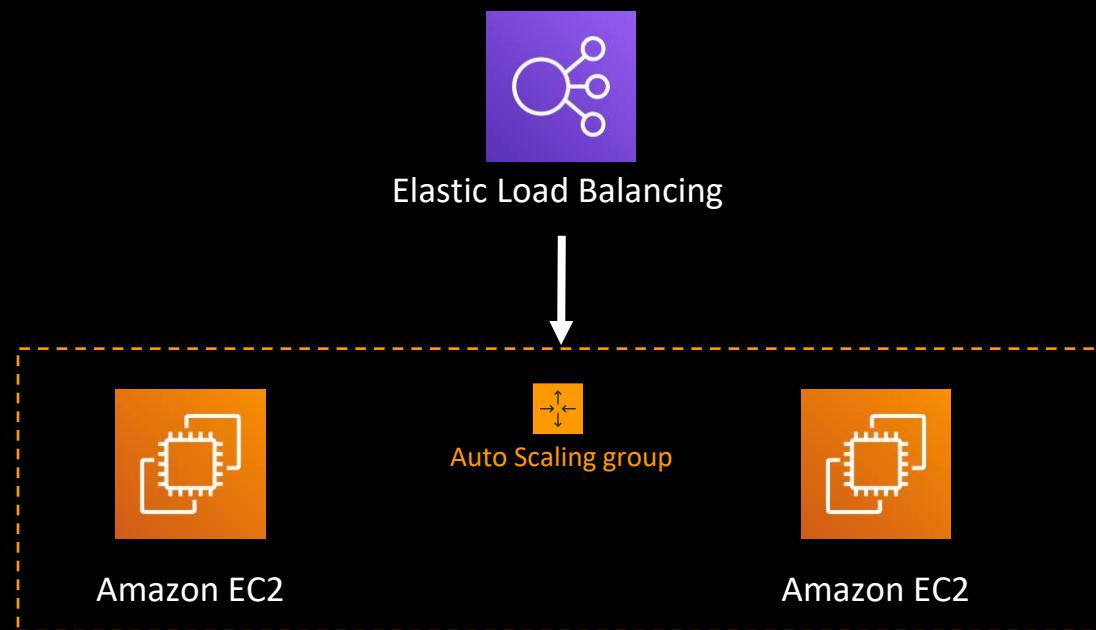
Let's Whiteboard!

Real World Interview Tips on Scaling

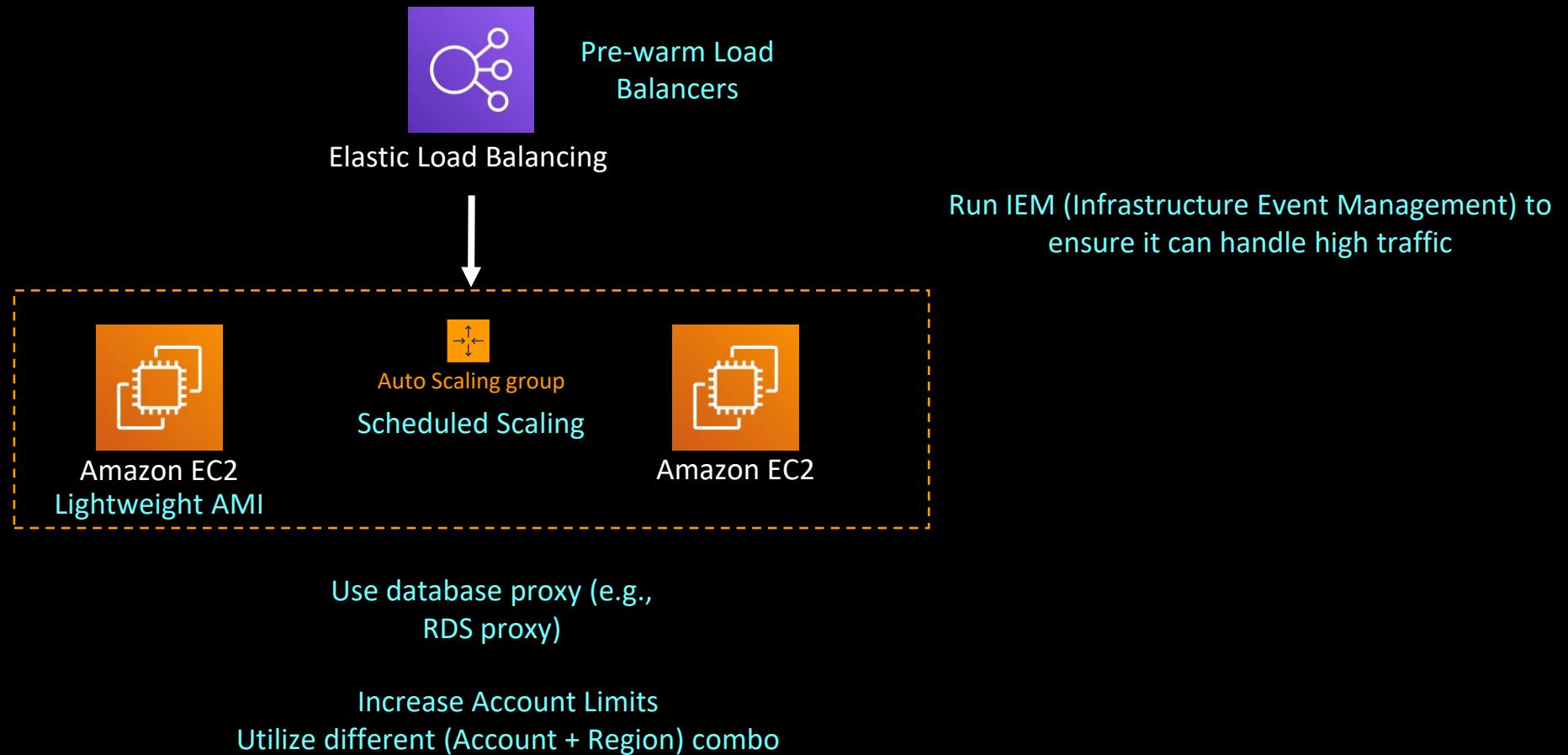
How can you make your application scalable for a big traffic day?

Average Answer

Put the VMs in auto scaling group and use load balancer



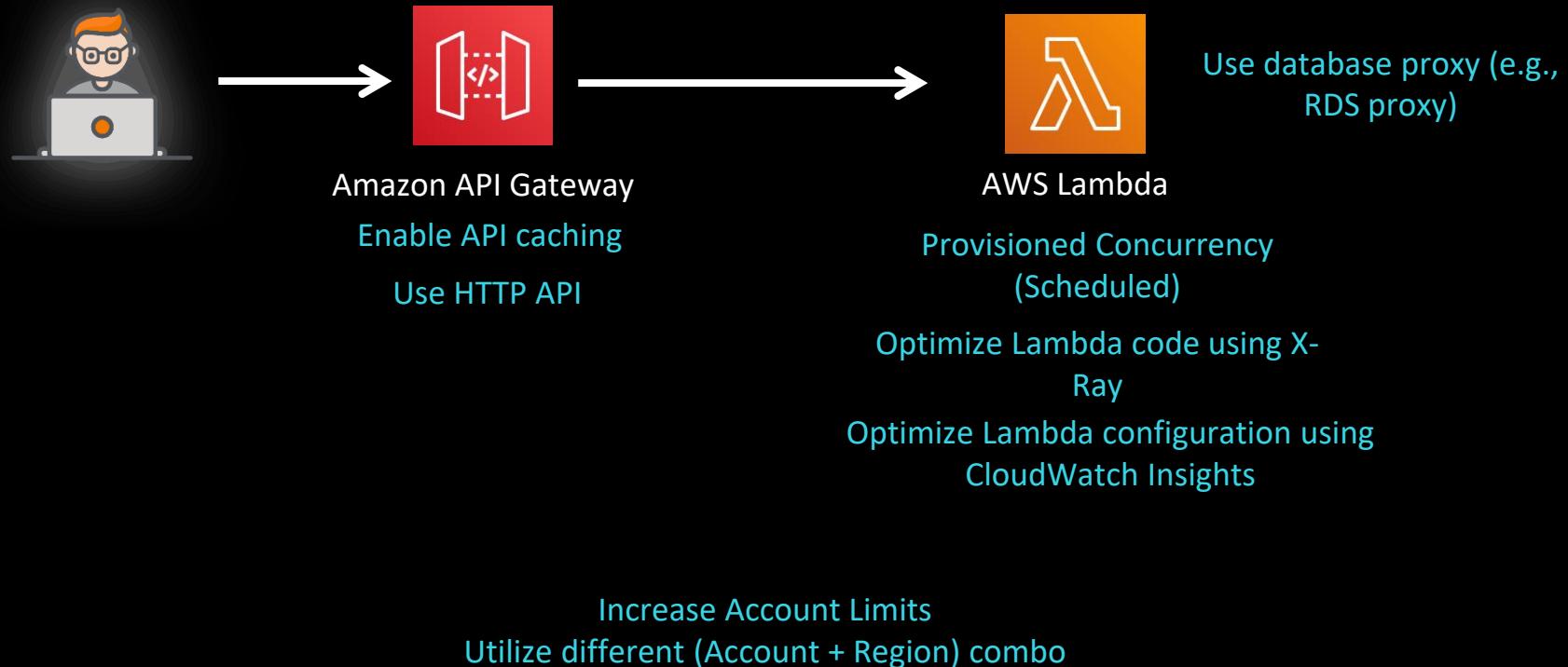
GOOD Answer



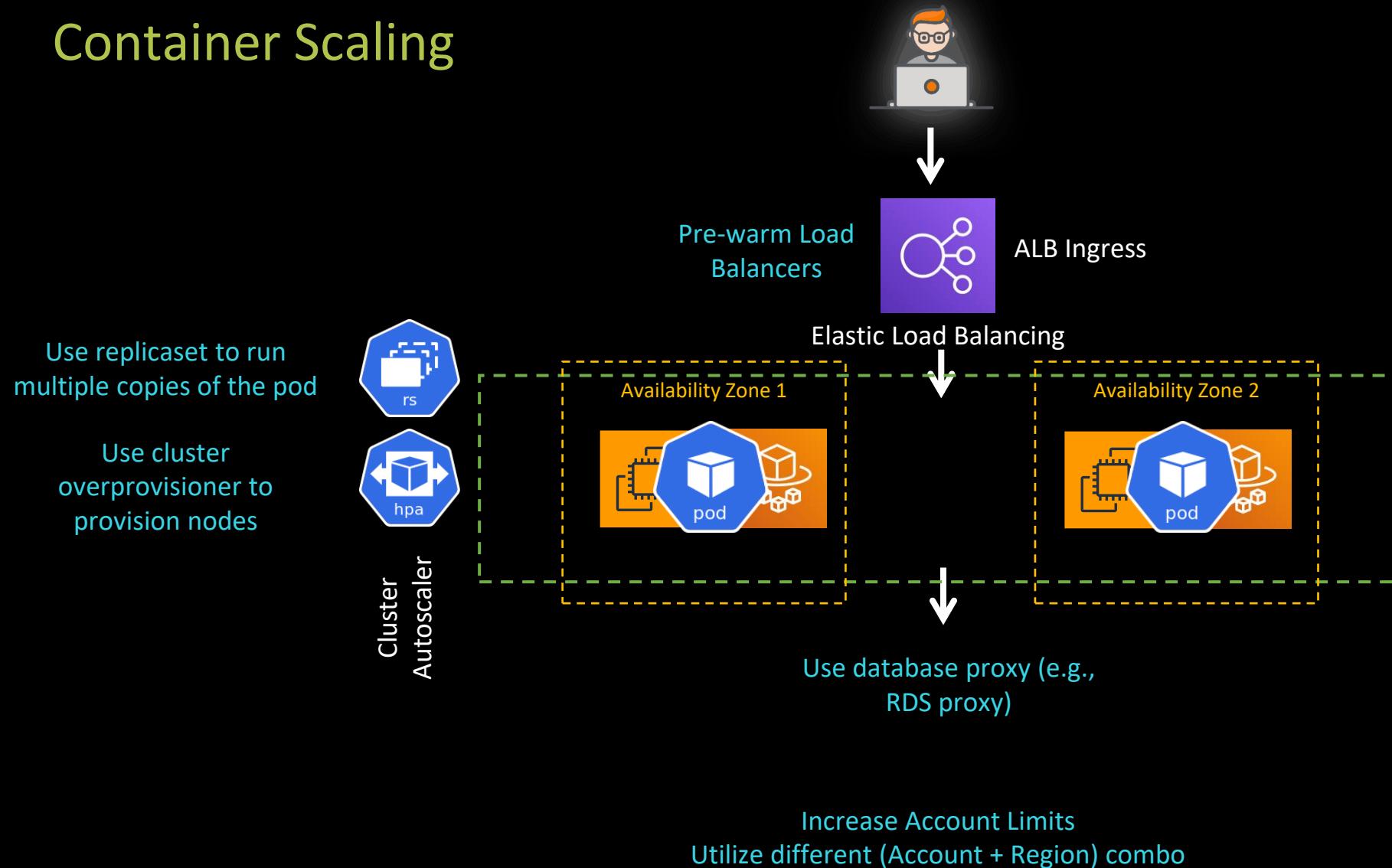
Talk about breaking the app into microservices

Going into Kubernetes or Serverless doesn't eliminate these challenges

Serverless Scaling

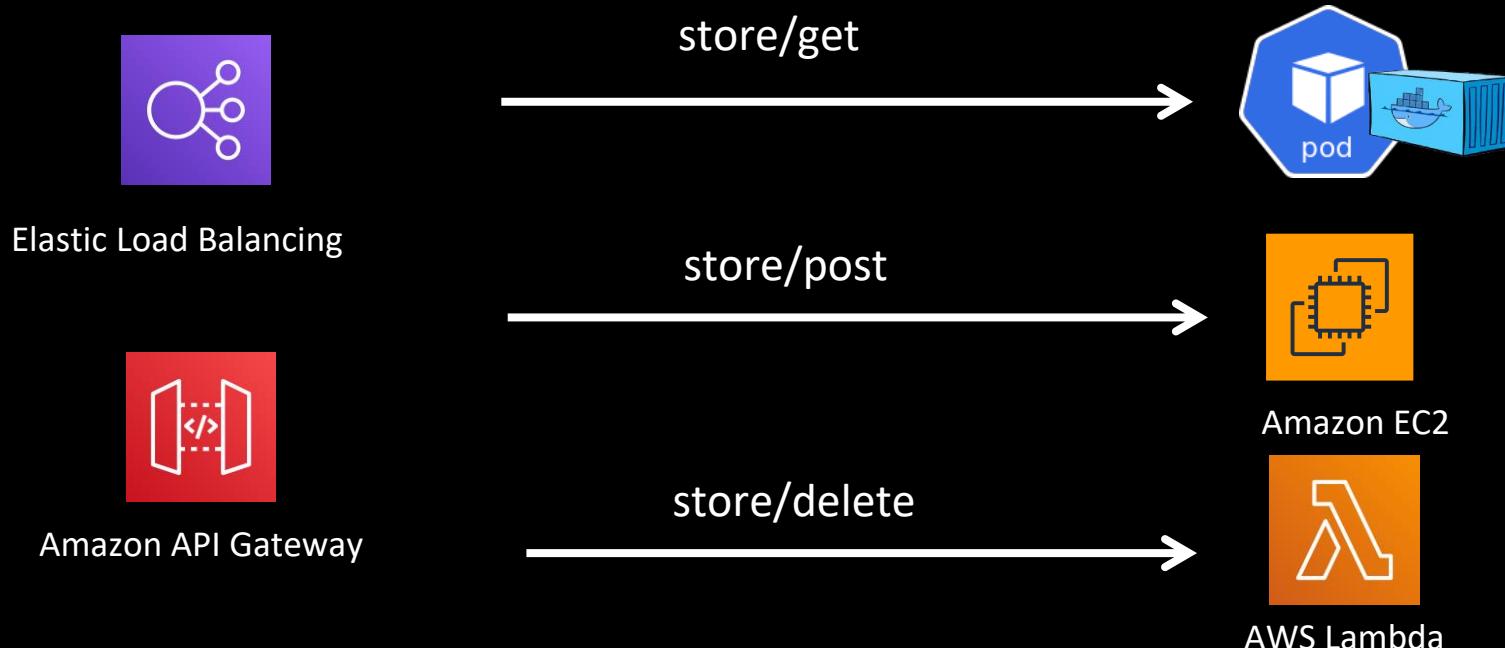


Container Scaling

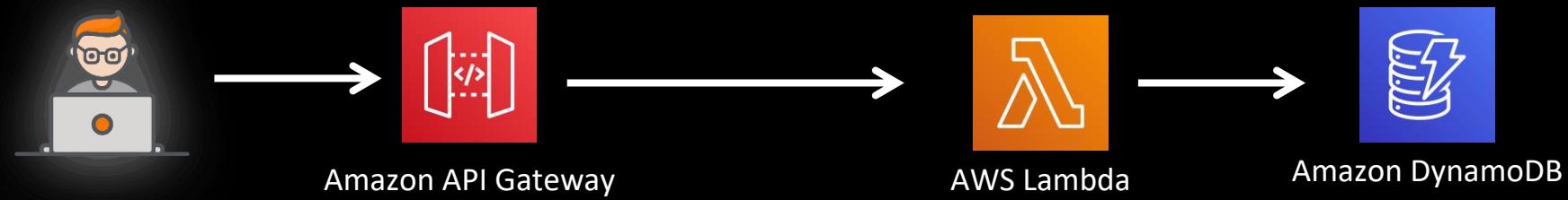


Synchronous vs. Event Driven/Async Architectures

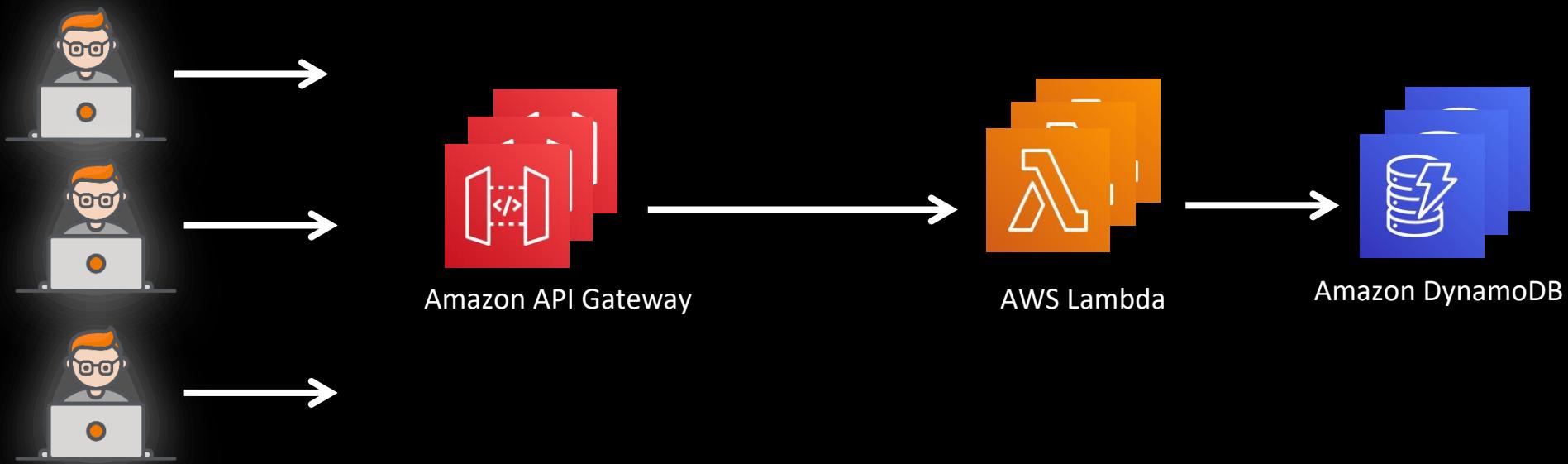
Microservices



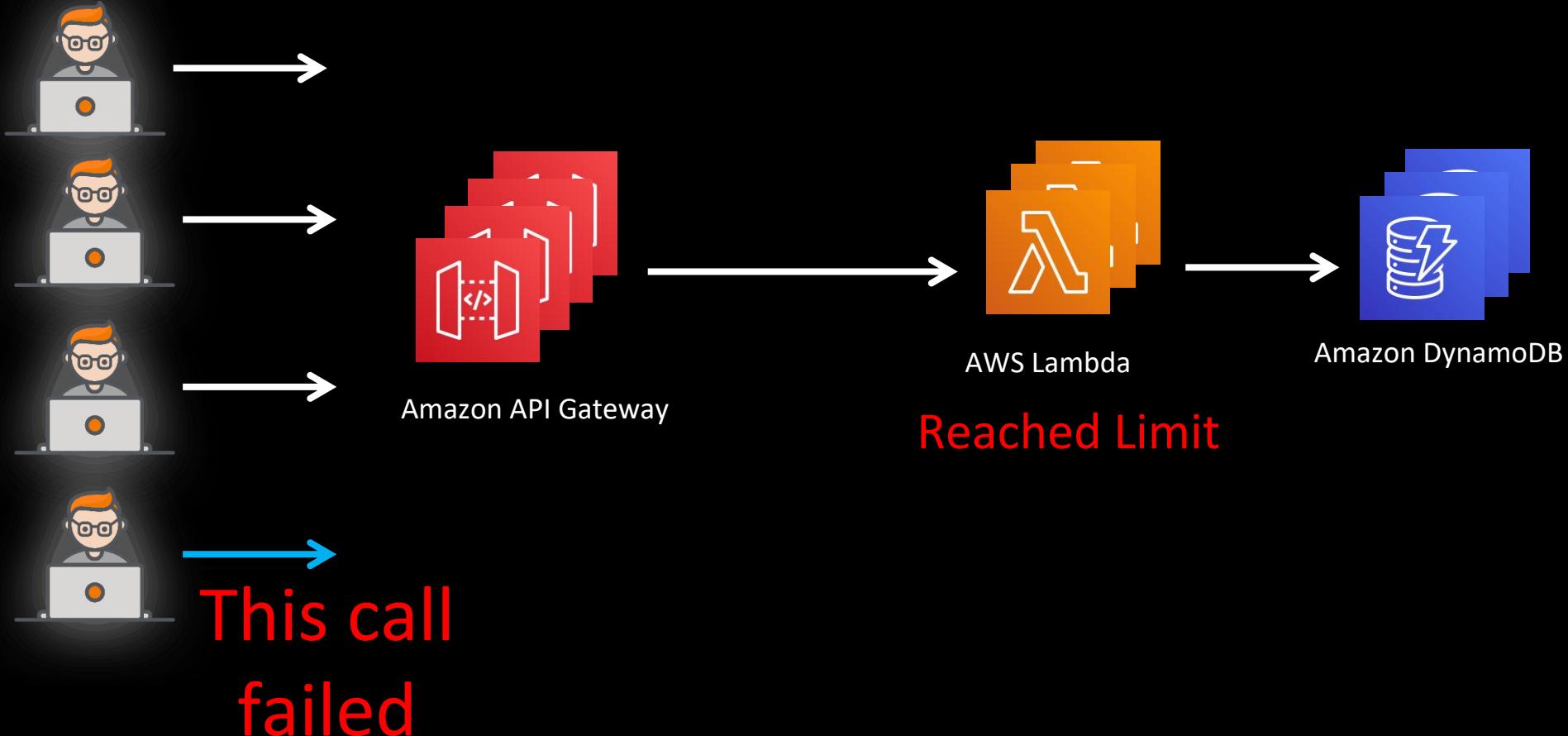
Synchronous Architecture



Synchronous Architecture



Synchronous Architecture



Synchronous Architecture



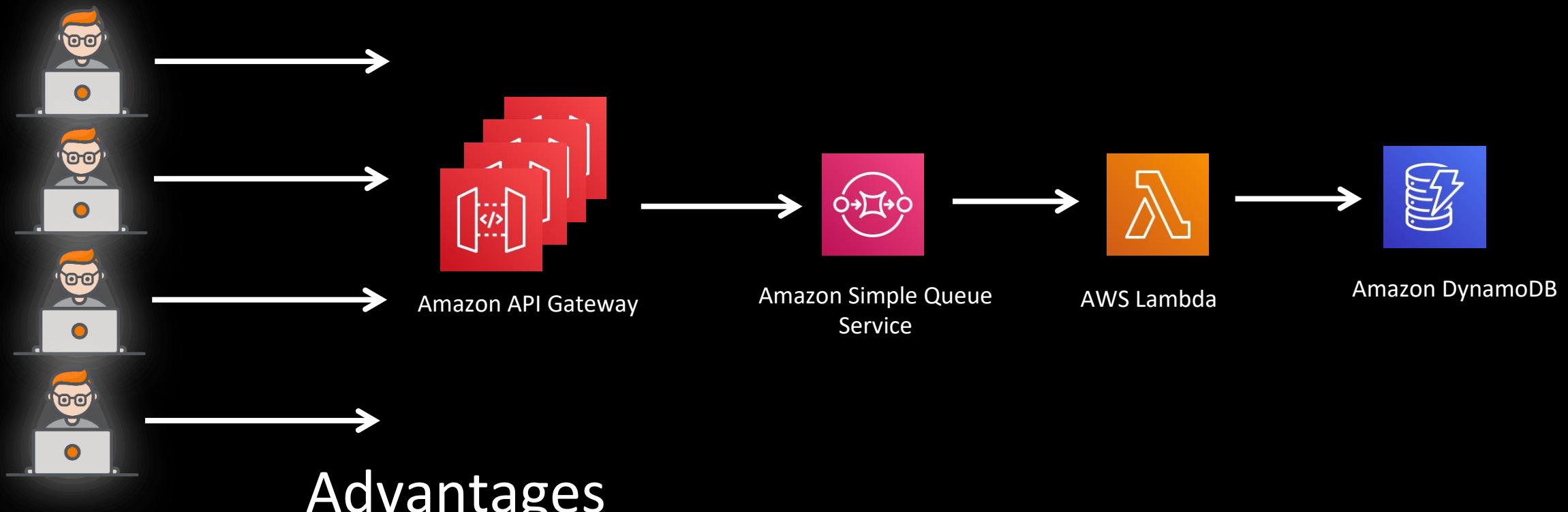
Challenges

- All components of Synchronous architectures MUST scale together
- Consumer needs to resend transaction for re-processing
- Expensive

Event-Driven/Async Architecture



Event-Driven/Async Architecture



Advantages

- Each component can scale independently
- Retry built in
- Cost effective than synchronous architecture

Stronger Together!

- Use synchronous and event-driven architectures where applicable
- Example ordering system
 - Order inserts can be done event-driven
 - Order status retrieval synchronously

PubSub Vs Queues

Streaming vs Messaging

SQL vs NoSQL

What We Going To Learn...

- SQL Vs NoSQL
- AWS Database Options
- Amazon Aurora Vs DynamoDB
- Conclusion

SQL Vs NoSQL Database

| SQL Database (RDBMS) | NoSQL Database |
|--|--|
| Tables have predefined schema | Schemaless |
| Holds structured data | Holds structured and unstructured data |
| Good fit for joins and complex queries | Generally, not good fit for complex multi table queries |
| Emphasizes on ACID properties (Atomicity, Consistency, Isolation and Durability) | Follows the Brewers CAP theorem (Consistency, Availability and Partition tolerance) |
| Generally, scales vertically | Generally, scales horizontally. AWS DynamoDB scales automatically! |

Schema Vs Schemaless

Schema

| Artist | Song Title | Album Title | Price | Genre | Critic Rating |
|--------|------------|-------------|-------|-------|---------------|
| | | | | | |

Schemaless

```
{  
  "Artist": "No One You Know",  
  "SongTitle": "My Dog Spot",  
  "AlbumTitle": "Hey Now",  
  "Price": 1.98,  
  "Genre": "Country",  
  "CriticRating": 8.4  
}
```

```
{  
  "Artist": "No One You Know",  
  "SongTitle": "Somewhere Down The Road",  
  "AlbumTitle": "Somewhat Famous",  
  "Genre": "Country",  
  "CriticRating": 8.4,  
  "Year": 1984  
}
```

```
{  
  "Artist": "The Acme Band",  
  "SongTitle": "Still in Love",  
  "AlbumTitle": "The Buck Starts Here",  
  "Price": 2.47,  
  "Genre": "Rock",  
  "PromotionInfo": {  
    "RadioStationsPlaying": [  
      "KHCR",  
      "KQBX",  
      "WTNR",  
      "WJJH"  
    ],  
    "TourDates": {  
      "Seattle": "20150625",  
      "Cleveland": "20150630"  
    },  
    "Rotation": "Heavy"  
  }  
}
```

```
{  
  "Artist": "The Acme Band",  
  "SongTitle": "Look Out, World",  
  "AlbumTitle": "The Buck Starts Here",  
  "Price": 0.99,  
  "Genre": "Rock"  
}
```

SQL Vs NoSQL in AWS

SQL DATABASES



Amazon Aurora



Amazon RDS

NOSQL DATABASES



Amazon DynamoDB



Amazon DocumentDB (with
MongoDB compatibility)



Amazon Managed
Apache Cassandra
Service

Note - You can always run your favorite non-AWS database on EC2

Amazon DynamoDB





Amazon Aurora

MySQL and PostgreSQL compatible relational database built for the cloud. 5 times faster than standard MySQL, 3 times faster than standard PostgreSQL at 1/10th the cost

Multi-Master Supported for MySQL

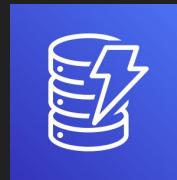
Cross region Active-Passive replication Supported for MySQL (Global Database)

Choosing Multi-AZ & Read Replicas provide High Availability

Vertical scaling. Serverless Aurora scales automatically, not as scalable as Dynamo.

Has integrated caches, can't be adjusted

Enable backups, snapshots for DR



Amazon DynamoDB

Key-value and document database with single-digit millisecond performance AT ANY SCALE

Multi-Master

Cross region Active-Active replication Supported (Global Tables)

Inherently replicates across three AZs - HA and Durable

Inherently Scalable, can handle more than 10 trillion requests/day & peaks of more than 20 million requests/second

Provides adjustable in-memory caching via DAX

Inherently durable, Point In Time Backups can be enabled

TAKING IT ALL IN - RIGHT TOOL FOR RIGHT JOB!

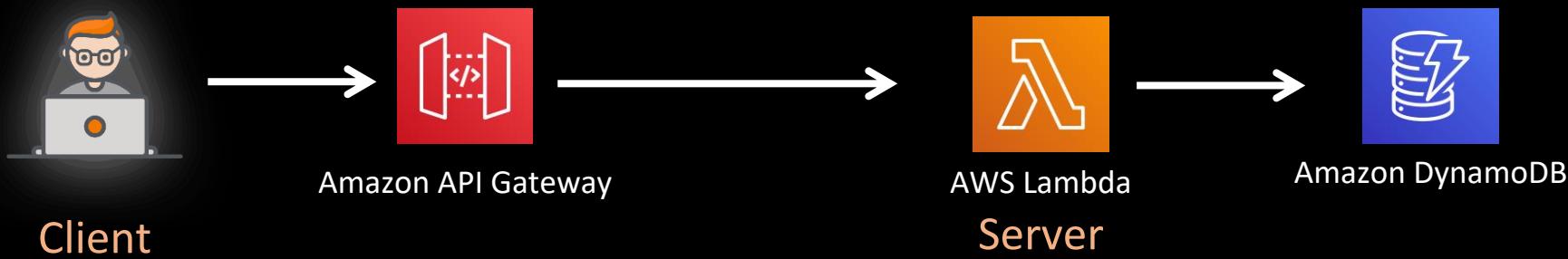


Do not use a cannon to kill a mosquito.

~ Confucius

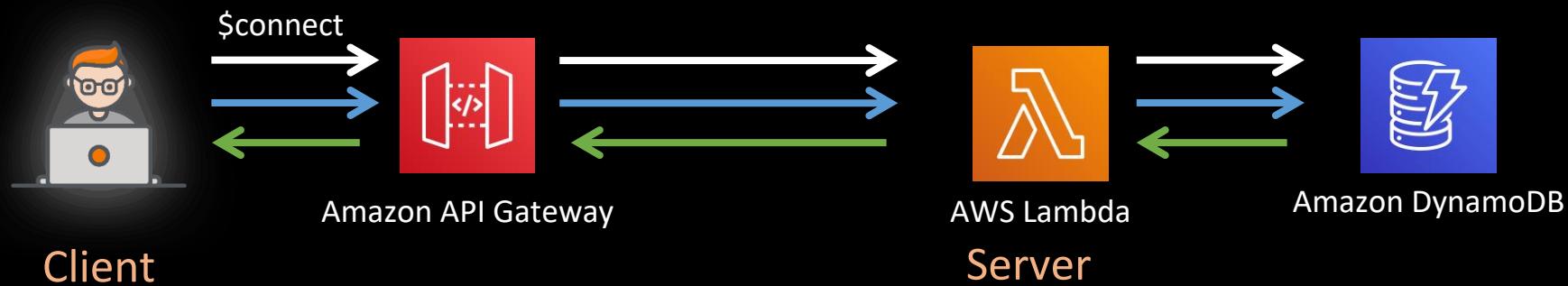
Websockets

Request-Response



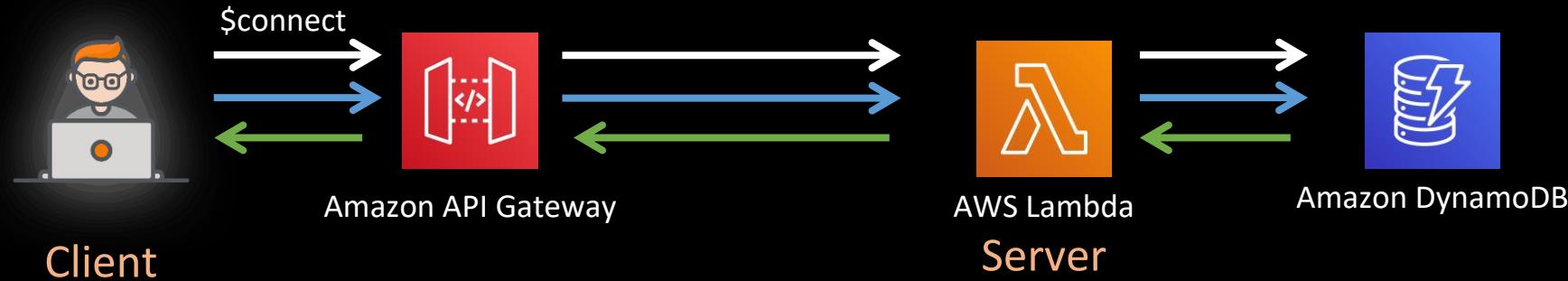
Only client can invoke server
Server can NOT initiate connection to client

Websocket



Connection stays open
Server can send messages to client
Can be achieved using Load Balancer and API Gateway

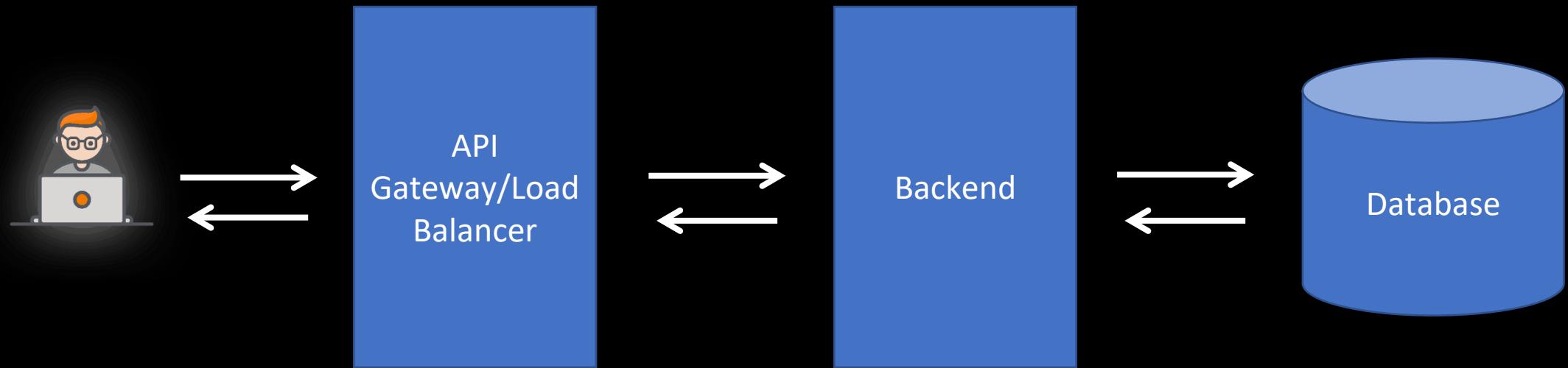
Websocket Use Cases



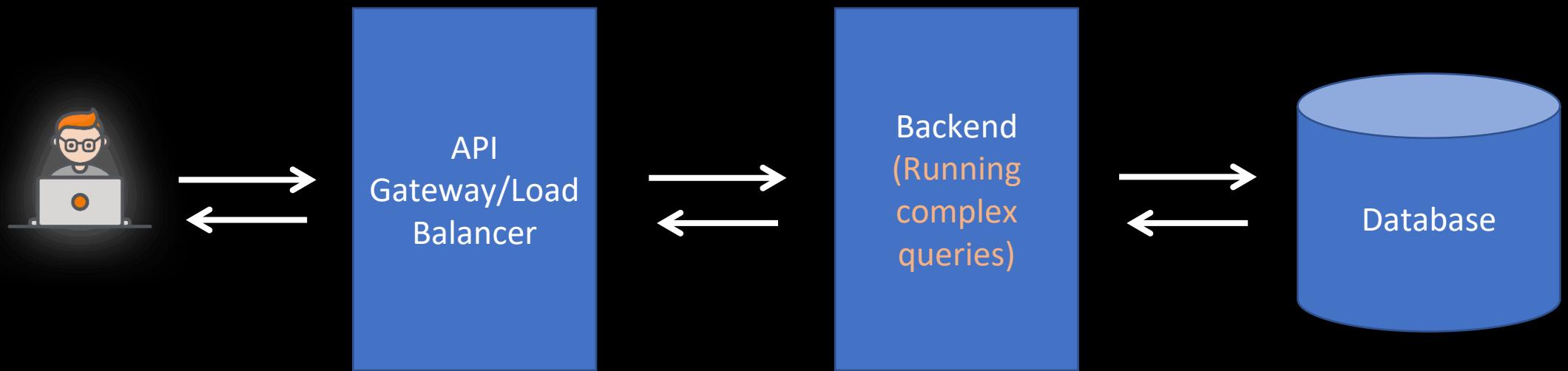
Chat applications – WhatsApp, Chatbots, Telegram

Caching

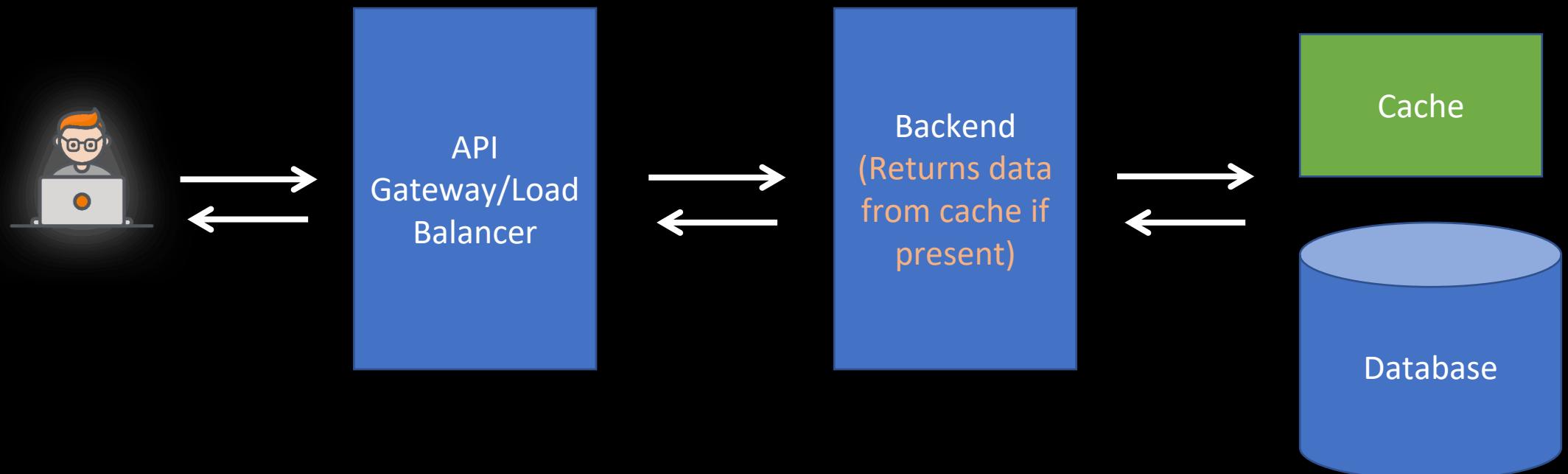
Caching – What and Why



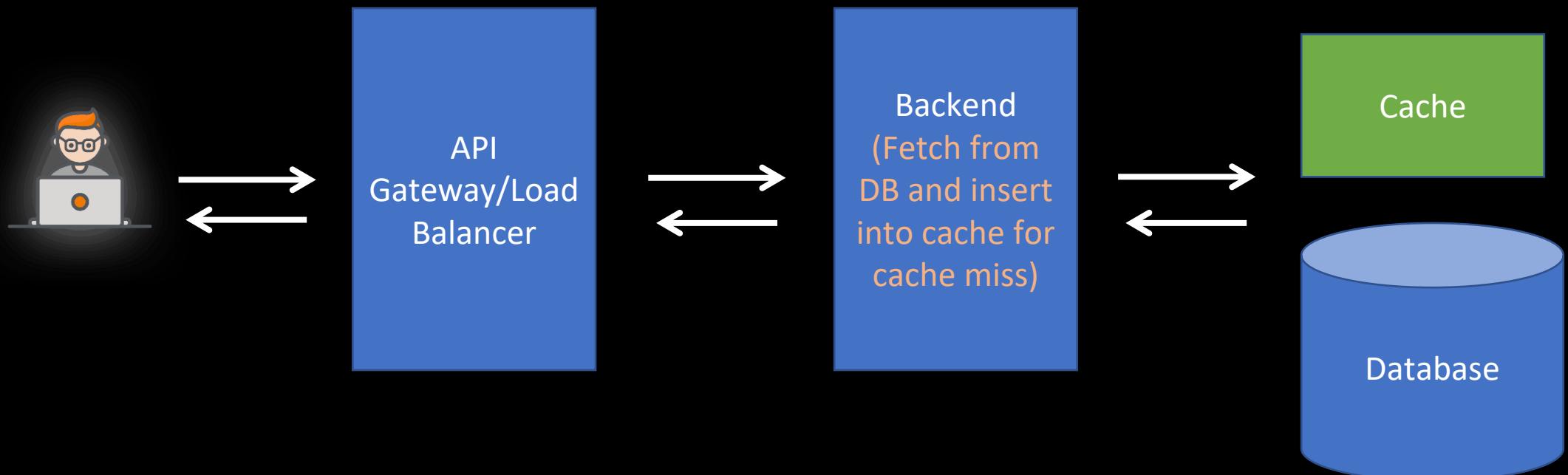
Caching – What and Why



Faster & Cost-efficient



How Does Cache get Populated?

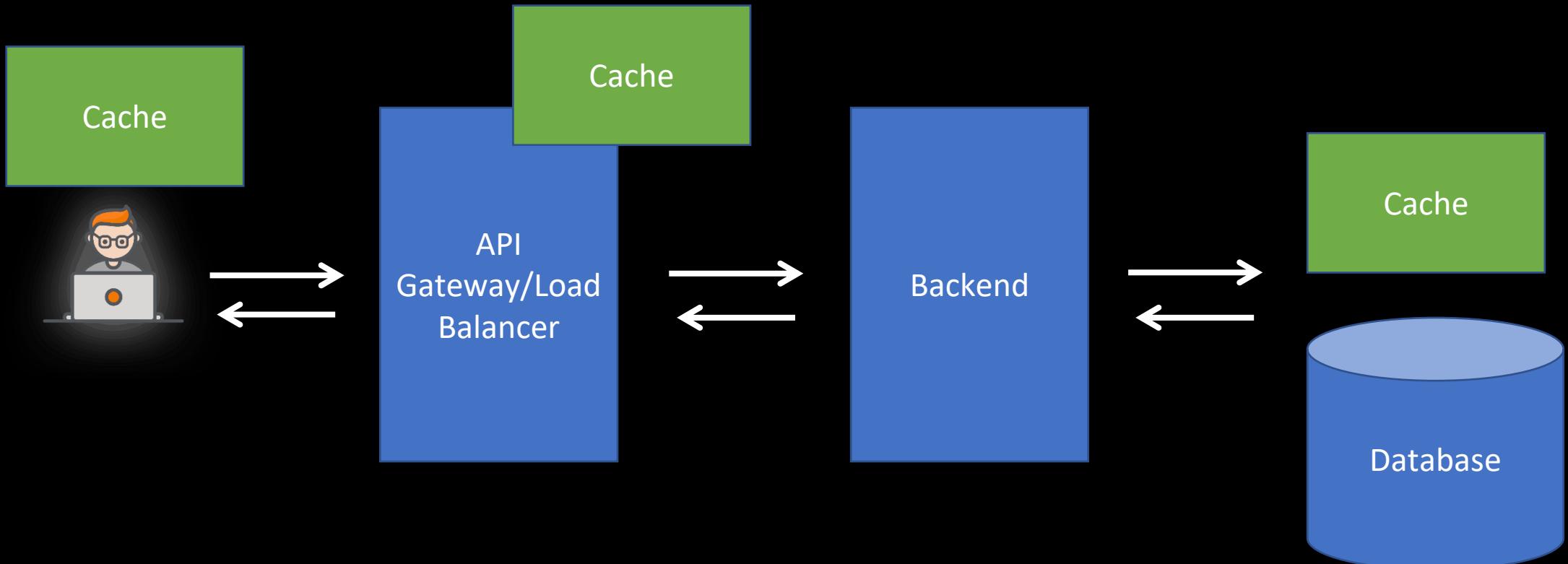


- Cache insert strategies later

How Does Cache get Deleted?

- Cache entries deleted after a specified time
- This is Time To Live (TTL)
- Cache entries can be updated with backend code
 - Think of cache like another database or file system

Cache is NOT restricted to Backend



Which Caching Service to Use When?

- Use managed caching of the service
- If service doesn't provide caching then use cache database



Amazon ElastiCache

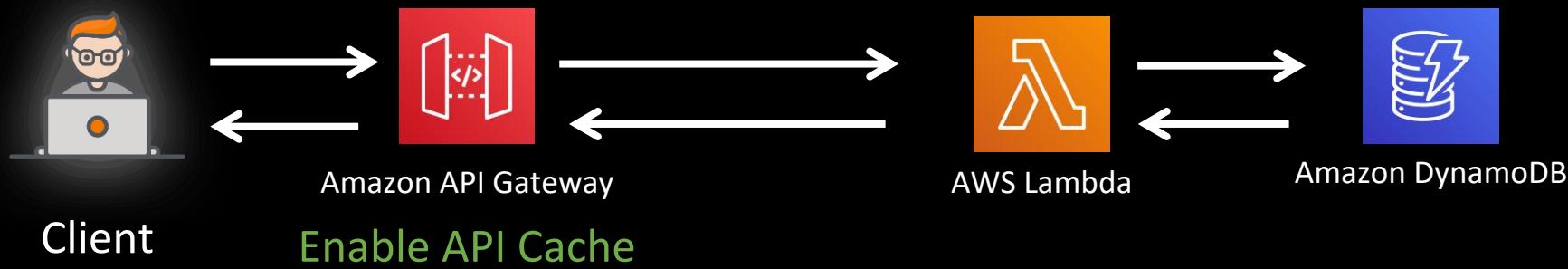


ElastiCache for
Redis

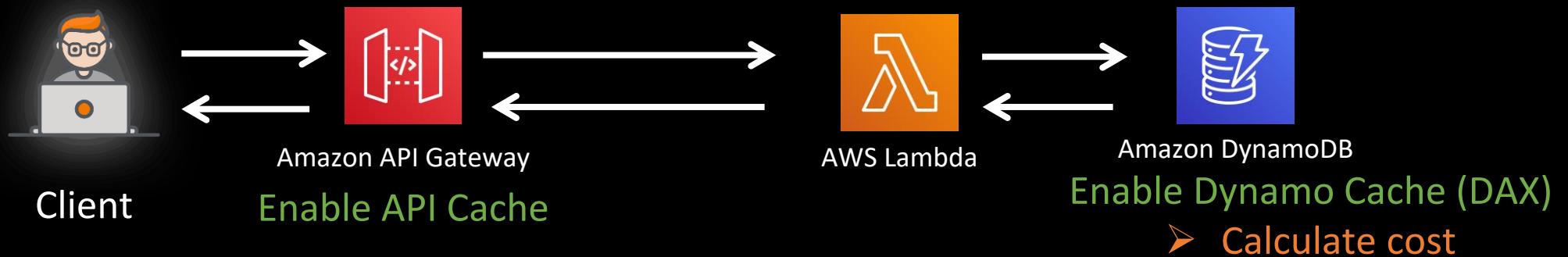


ElastiCache for
Memcached

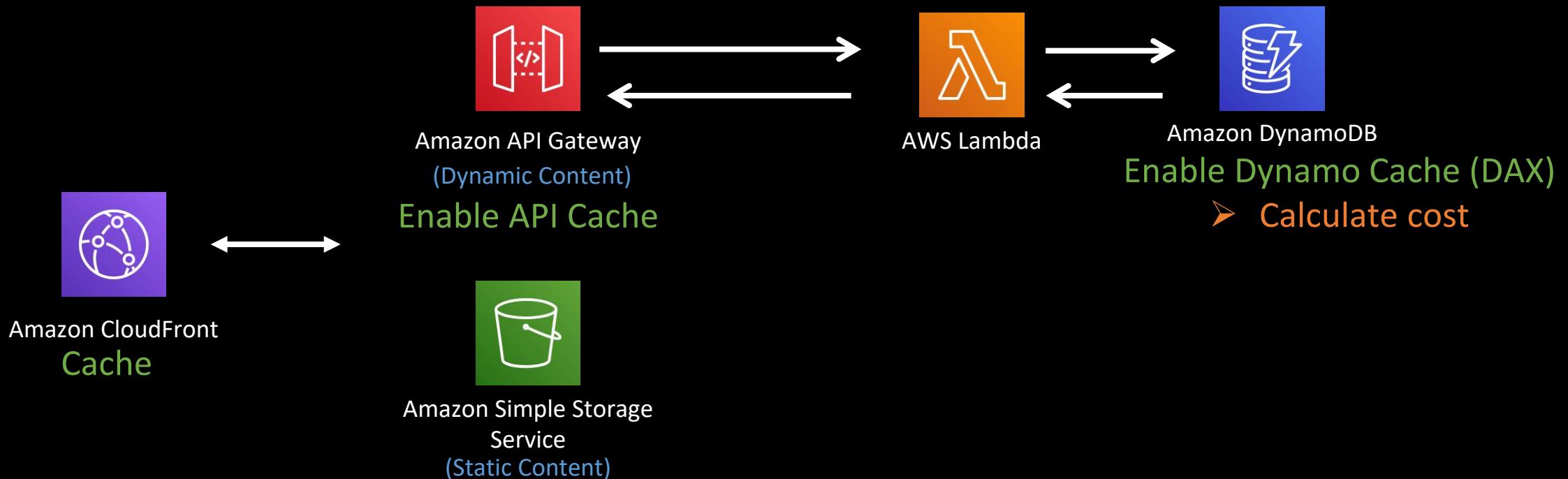
Using Caching on AWS Services



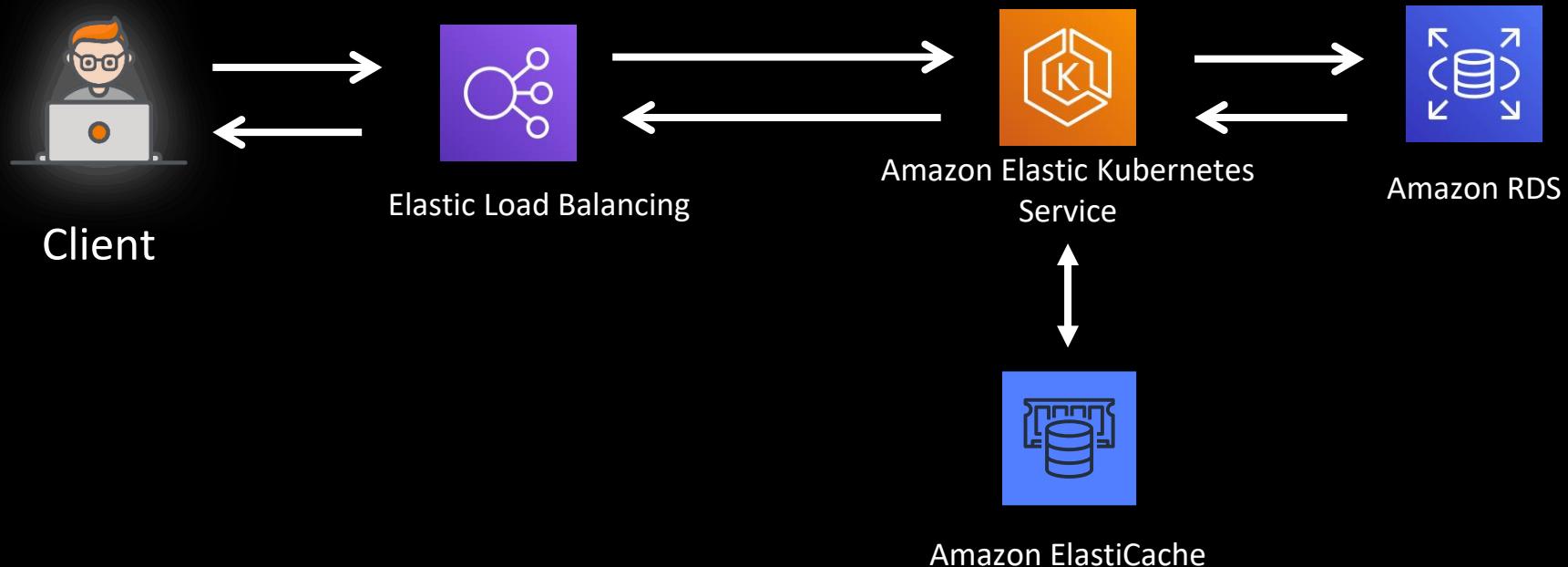
Using Caching on AWS Services



Using Caching on AWS Services



Using Caching on AWS Services



Redis Memcached & Caching Strategies

Memcached vs. Redis

Memcached

Simple data types

Large nodes with multiple cores or threads

Ability to scale out/in

Can cache object

Redis

Complex data types

Sort or rank in-memory datasets

Replicate data

Automatic failover

Backup and restore

Publish and subscribe

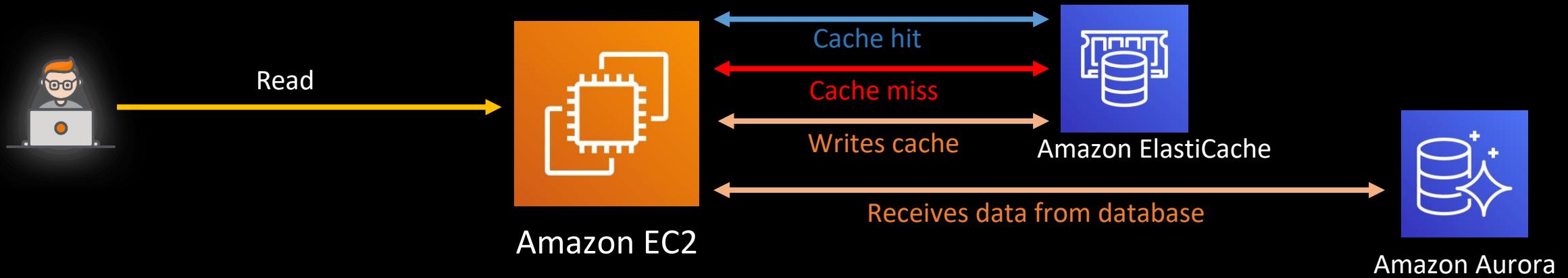
Support multiple databases

ElastiCache Use Cases

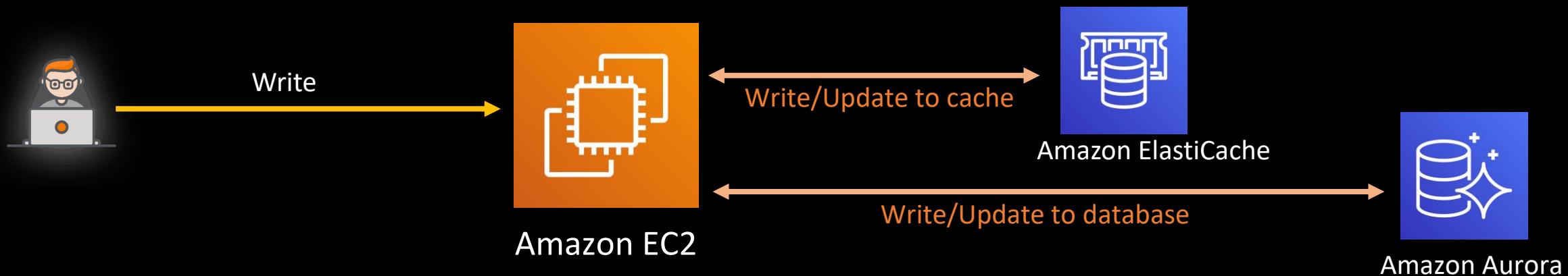
- Cache frequently accessed data – user profile, preferences, item descriptions etc.
- Gaming leaderboards, real-time recommendations, messaging, and more



Lazy Loading



Write-Through



High Availability

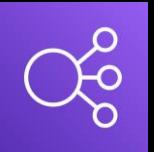
High Availability

- System continues functioning even when some of its components fail
- System guarantees certain percentage of uptime

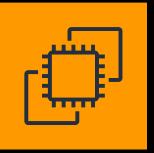
Identifying Single Point of Failure

- Servers running your applications
- Database
- Load balancer
- Analyze each component and validate single point of failure

Achieving High Availability on Cloud



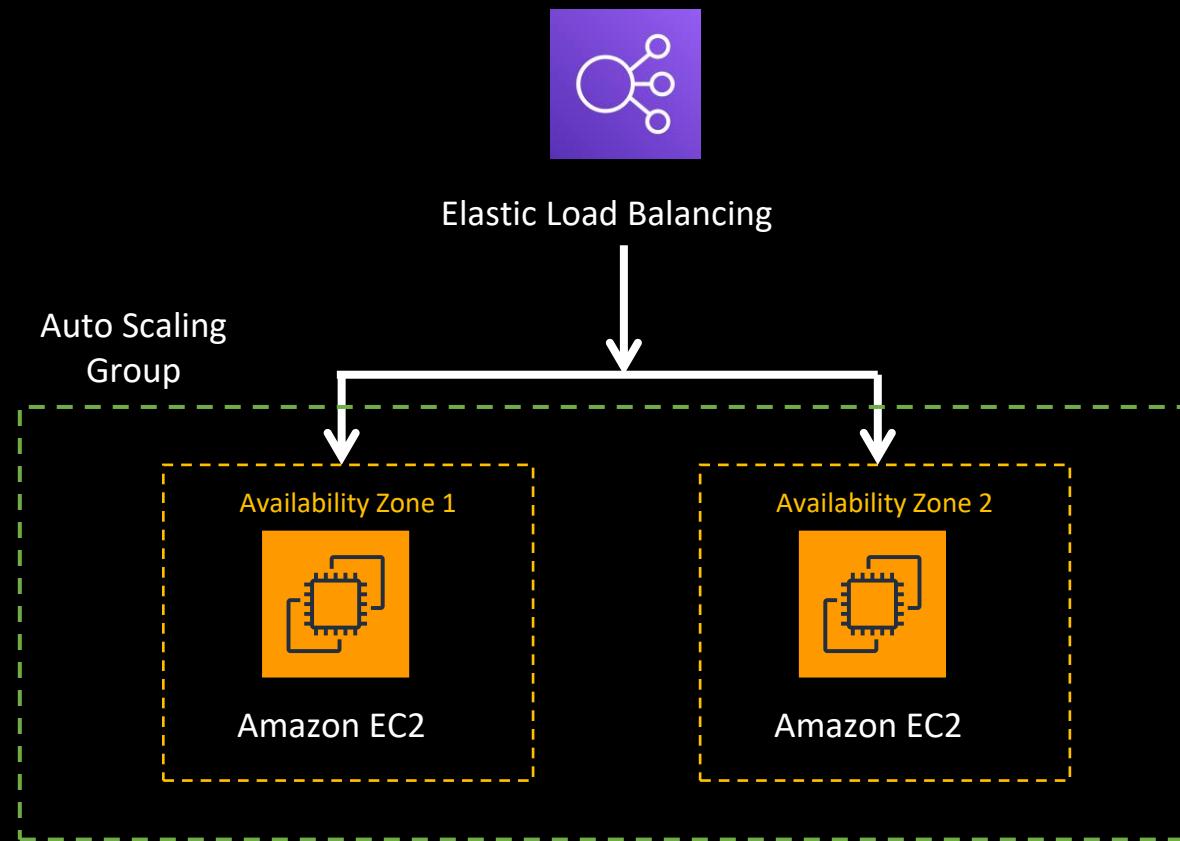
Elastic Load Balancing



Amazon EC2

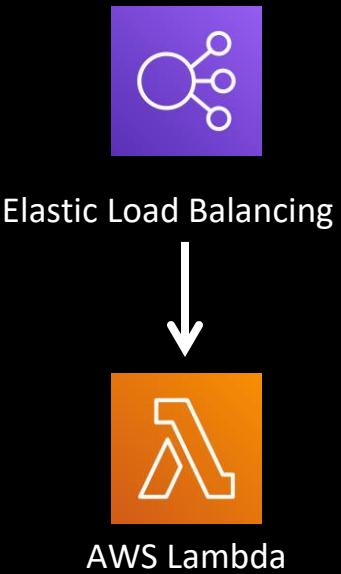
- Elastic Load Balancer is inherently highly available (managed by Cloud Provider)
- Auto Scaling Group makes the server scalable, not highly available
 - There is a delay to spin server up

Achieving High Availability on Cloud



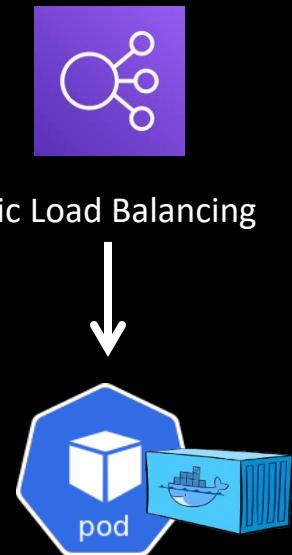
- Achieve high availability but costs extra money
- What is an option which is automatically highly available i.e. HA managed by Cloud Provider?

Achieving High Availability on Cloud



- How about Kubernetes?

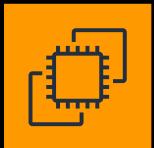
Achieving High Availability on Cloud



Achieving High Availability on Cloud



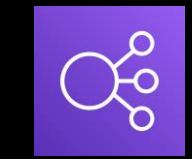
Elastic Load Balancing



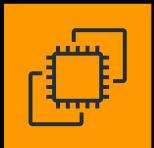
Amazon EC2



Achieving High Availability on Cloud



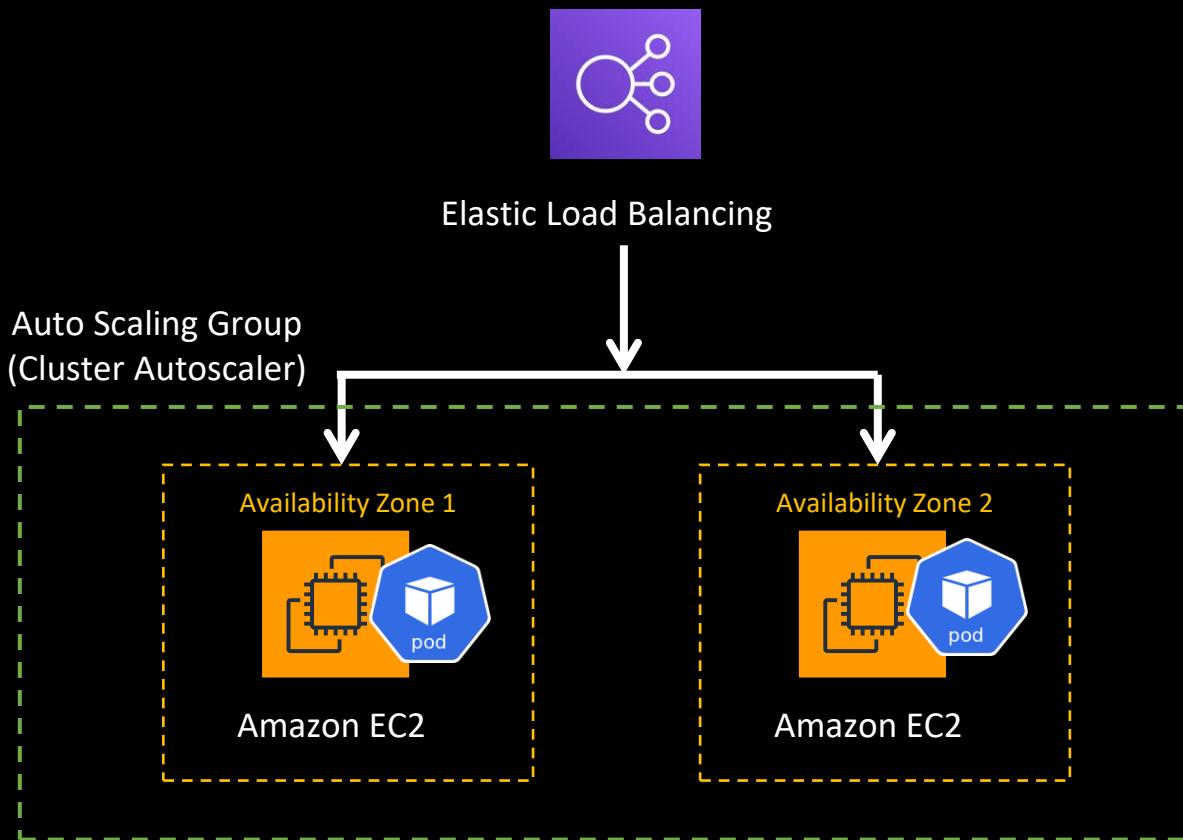
Elastic Load Balancing



Amazon EC2



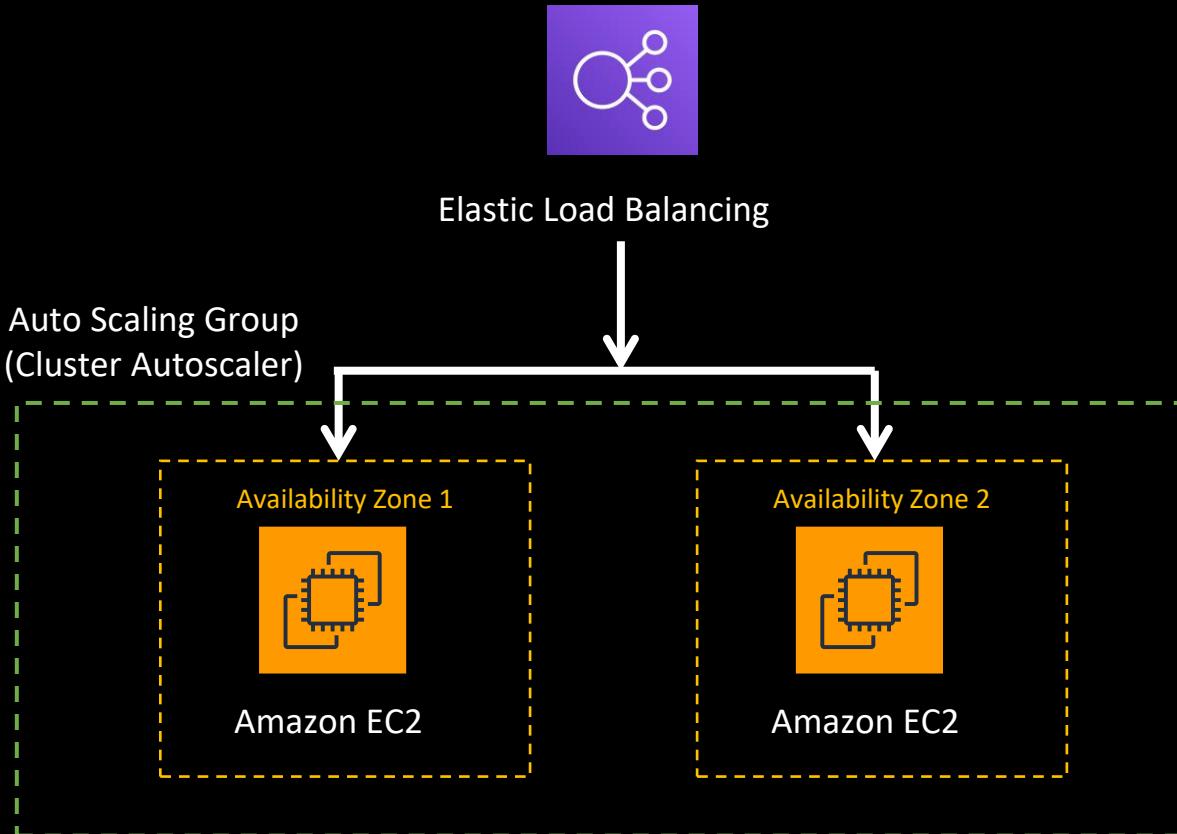
Achieving High Availability on Cloud



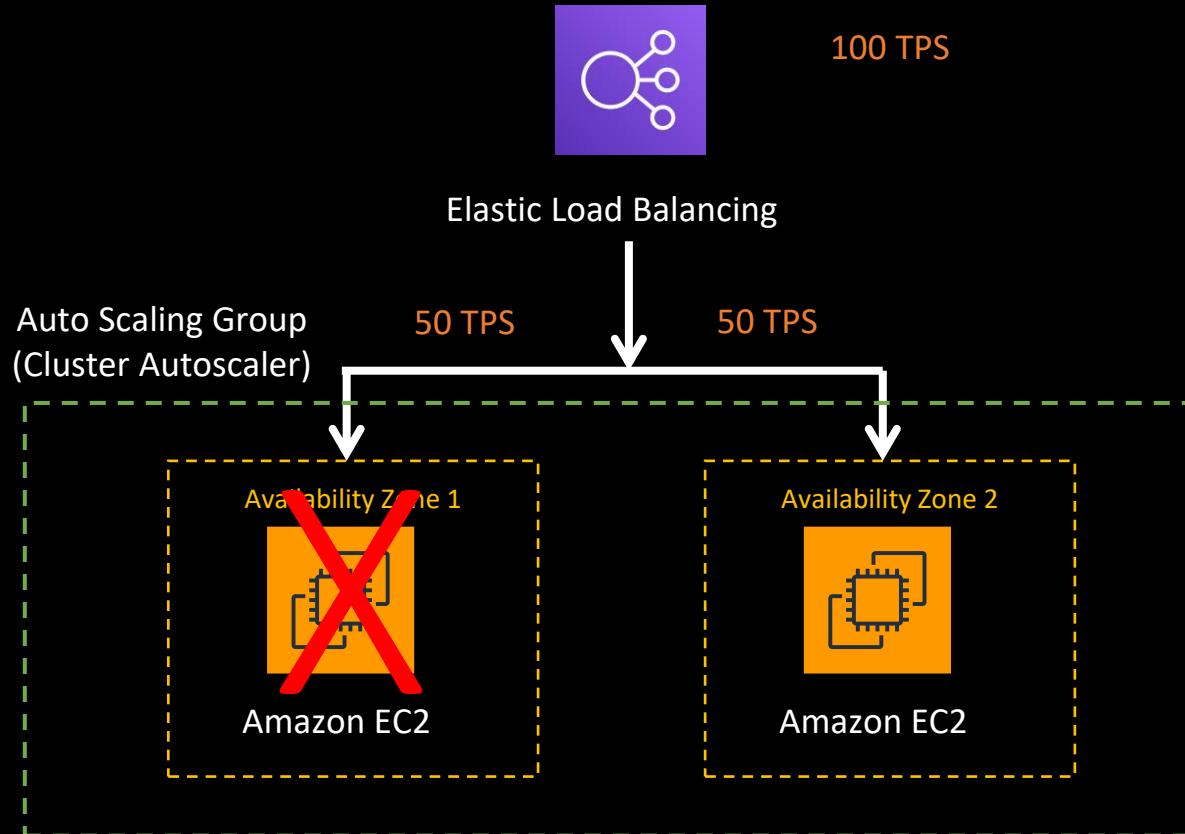
- Don't over index on cost when you design or answer interview question

High Availability Vs Fault Tolerance

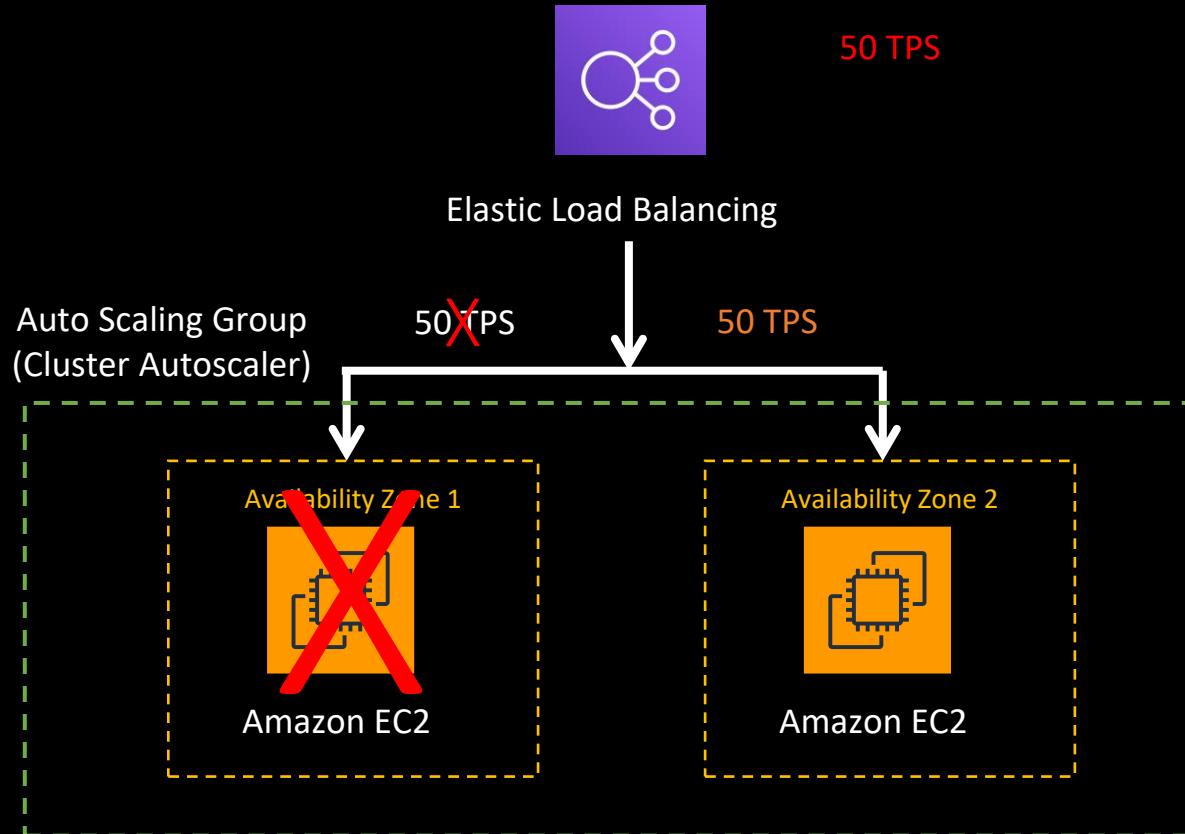
High Availability



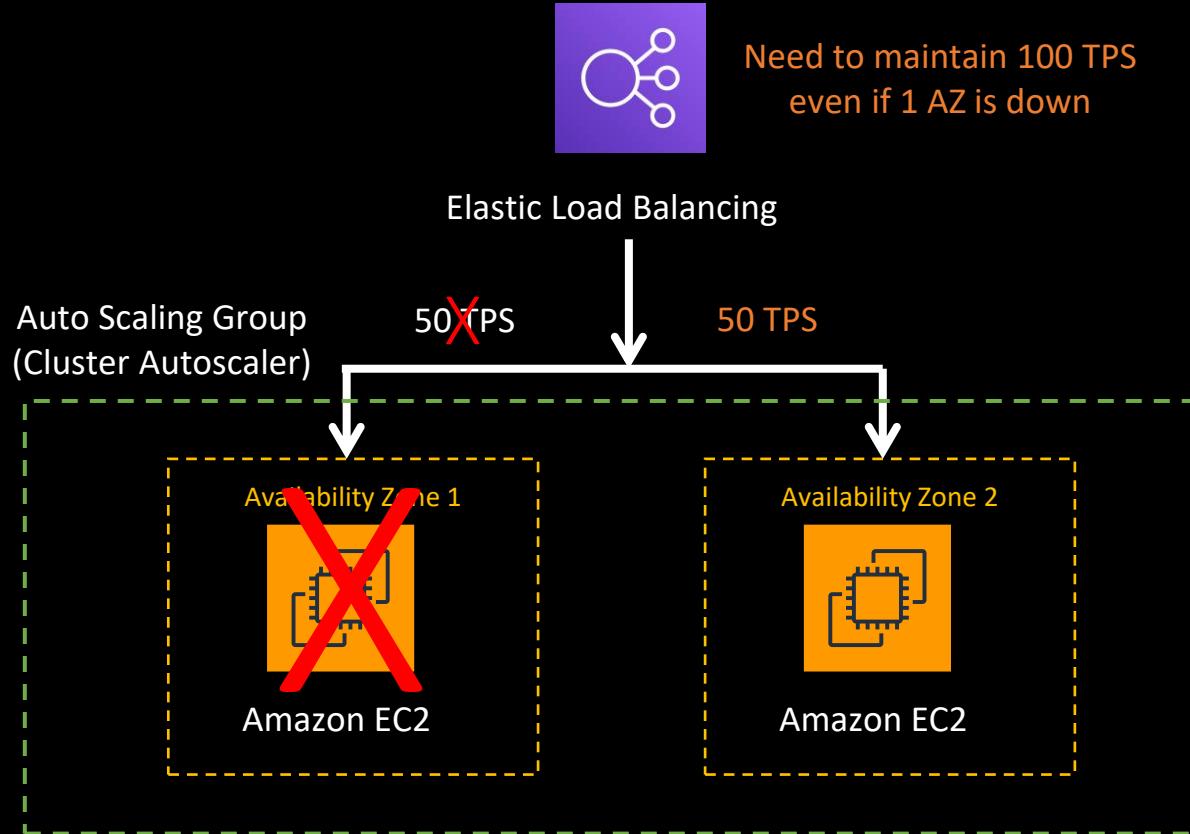
High Availability



High Availability



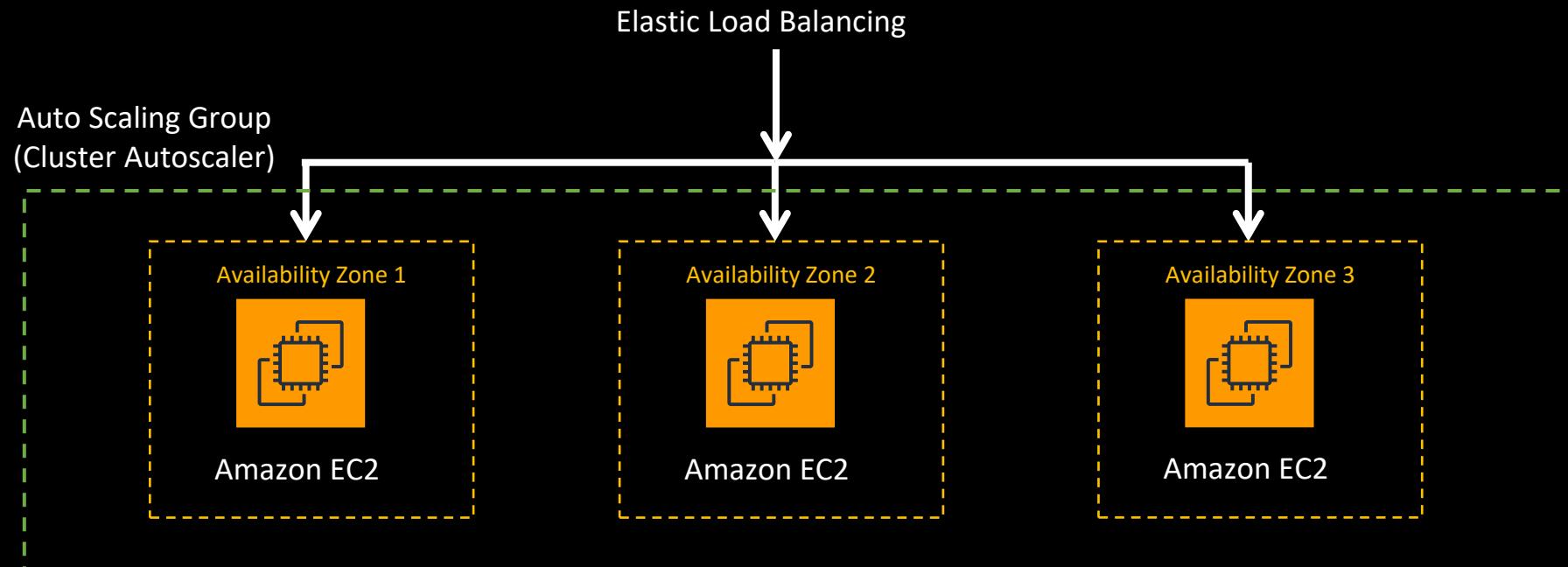
Fault Tolerant



Fault Tolerant



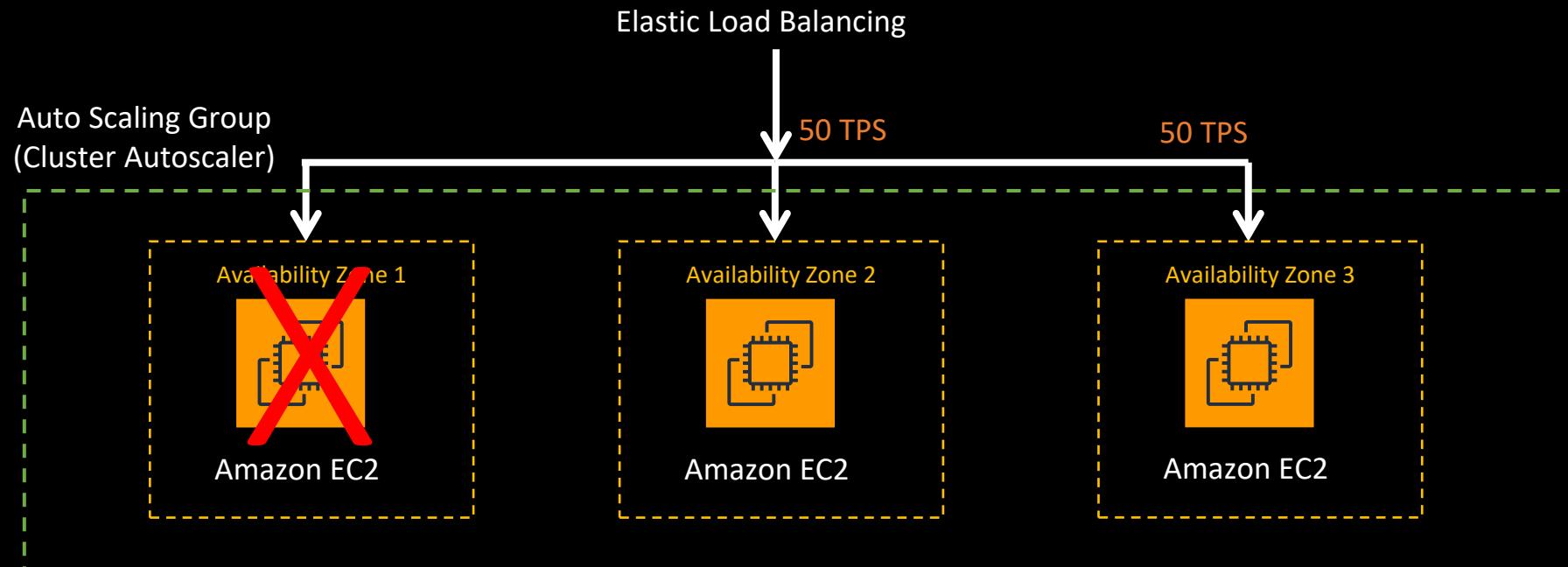
Need to maintain 100 TPS
even if 1 AZ is down



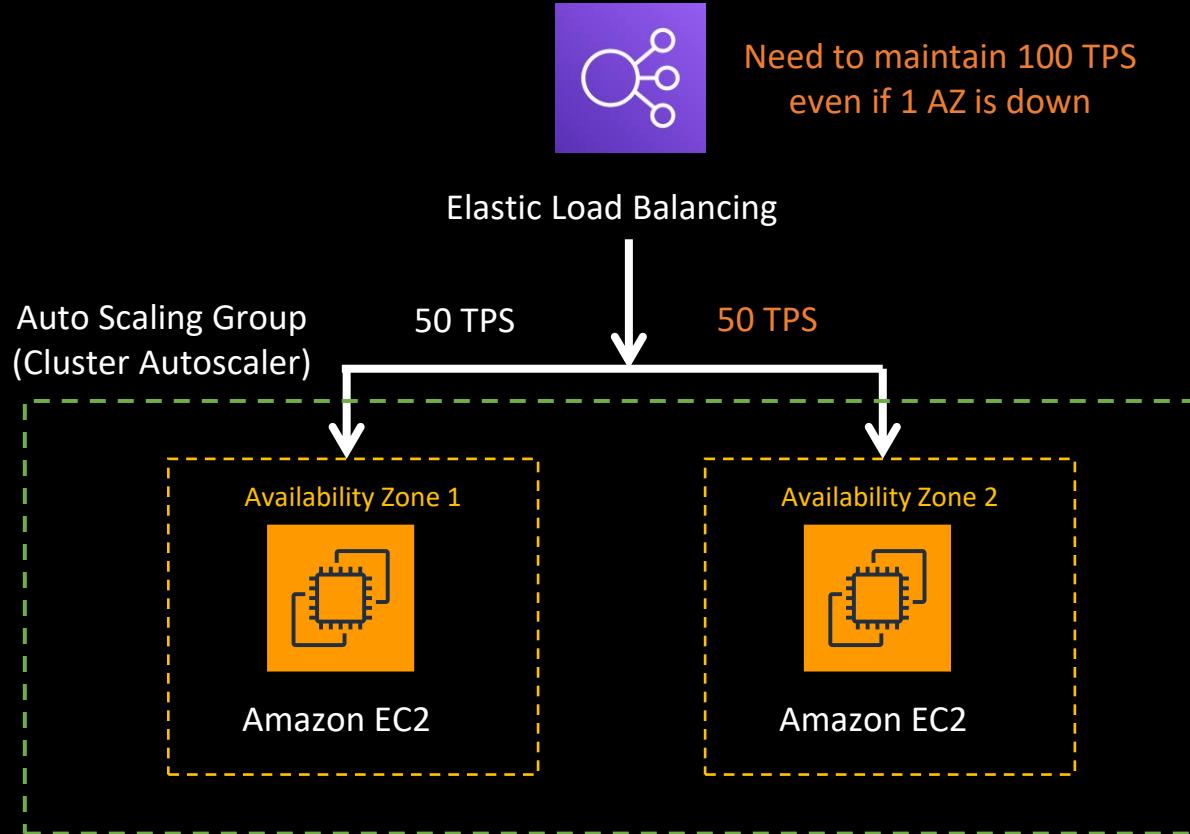
Fault Tolerant



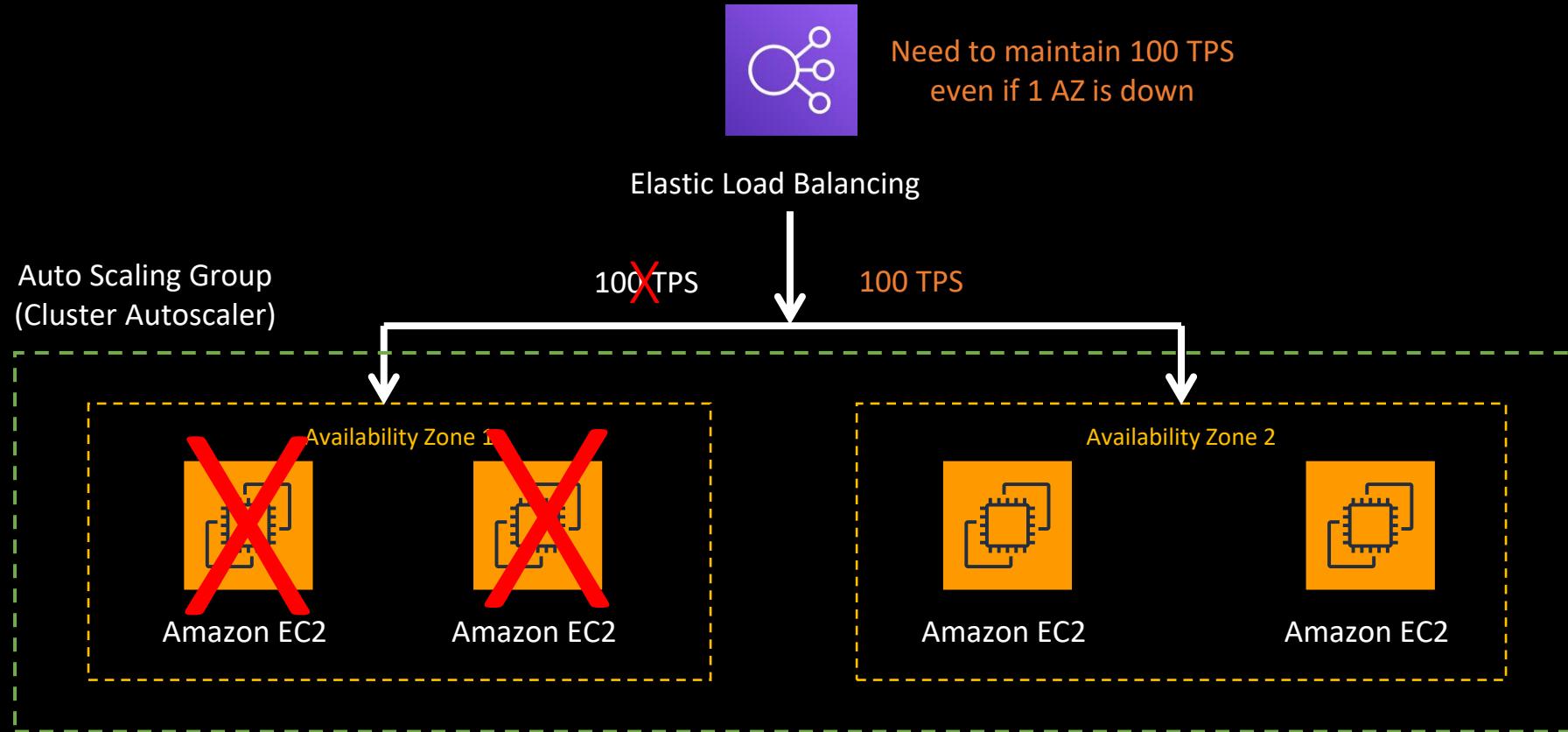
Need to maintain 100 TPS
even if 1 AZ is down



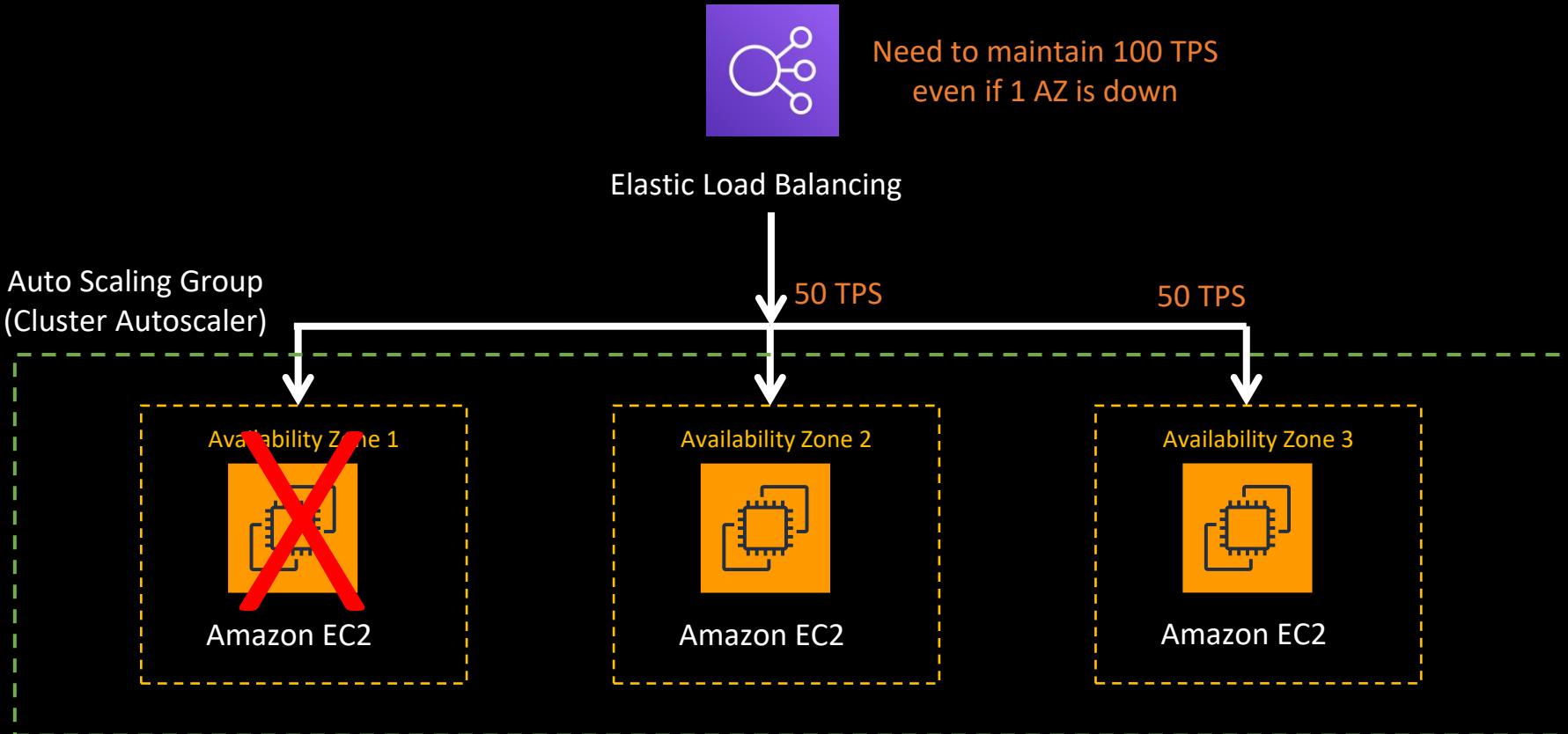
Fault Tolerant



Fault Tolerant



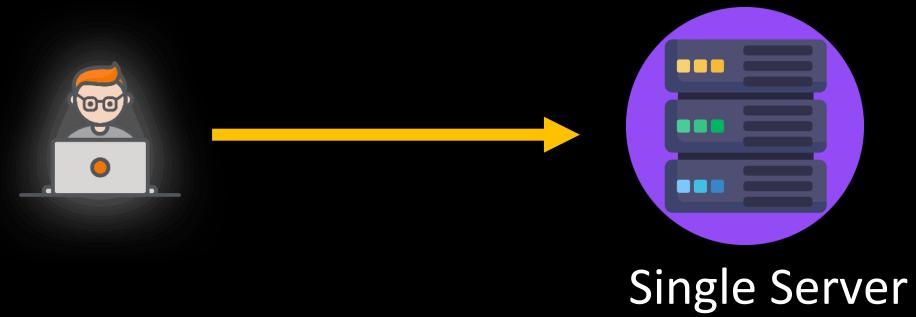
Fault Tolerant



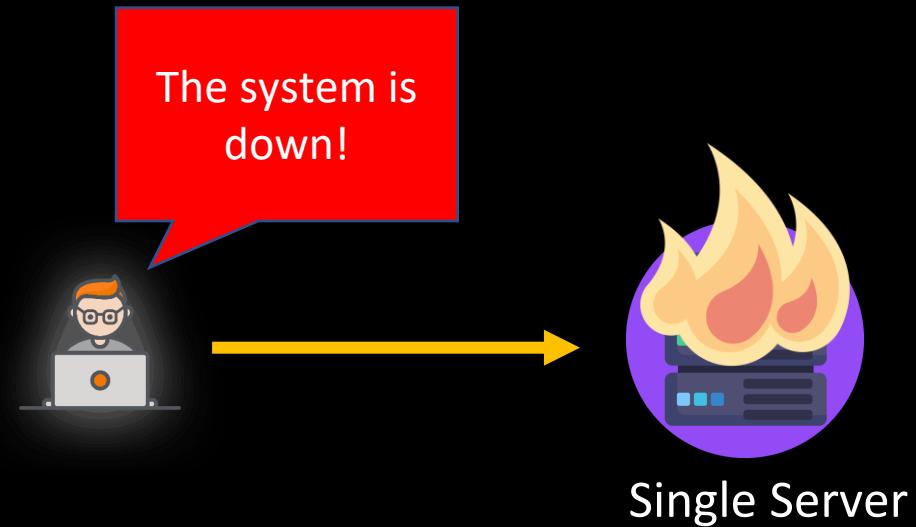
- Fault tolerant system is more expensive than highly available system

Distributed Systems

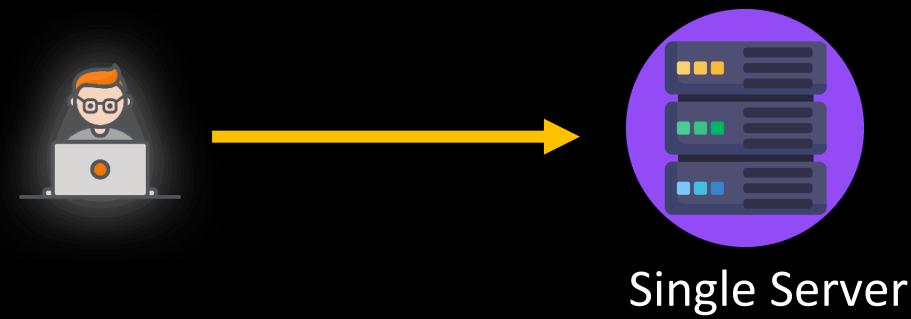
Centralized Systems



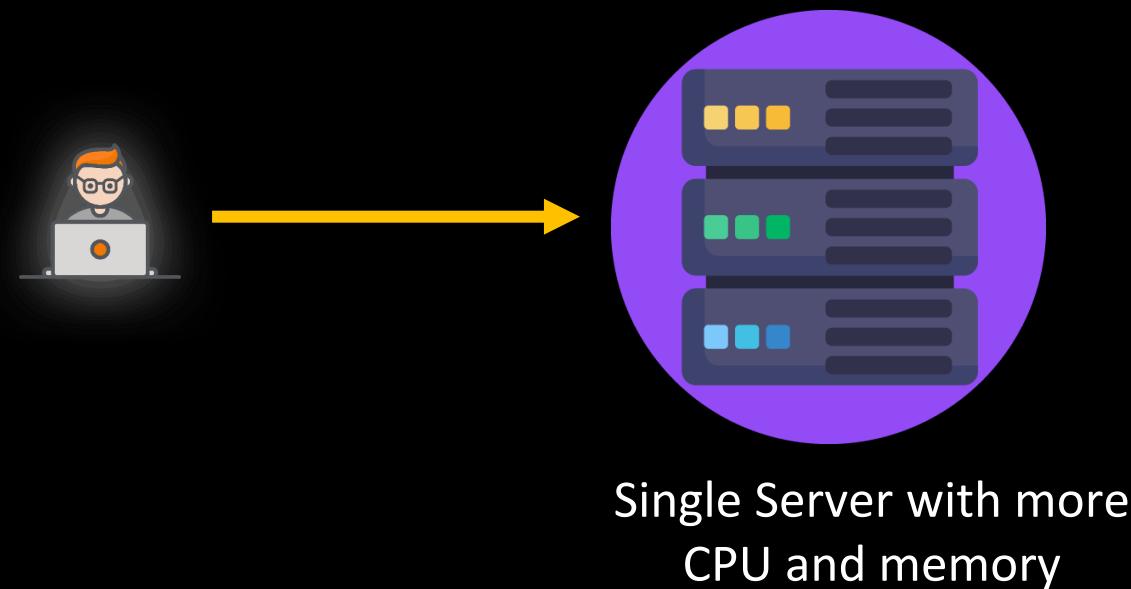
Single Point of Failure



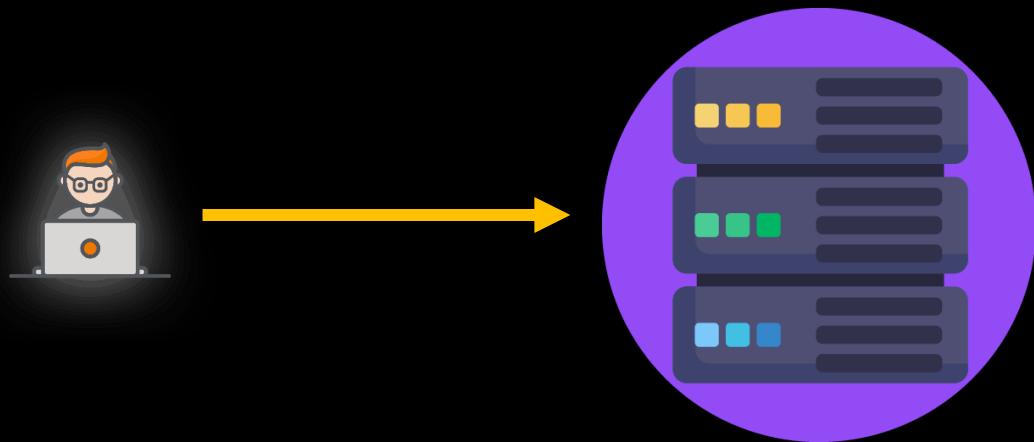
Centralized Systems Scaling



Centralized Systems Scaling



Centralized Systems Examples



Single Server with more
CPU and memory



Apps on local machine

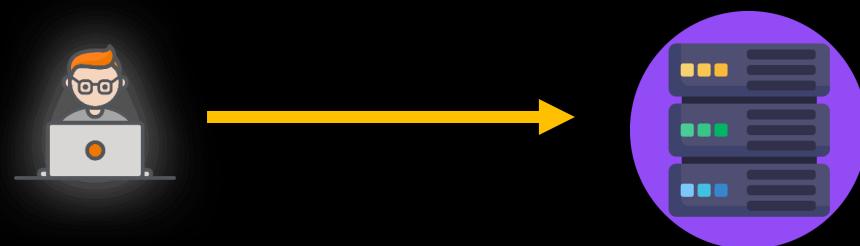


IBM DB2 on Mainframe

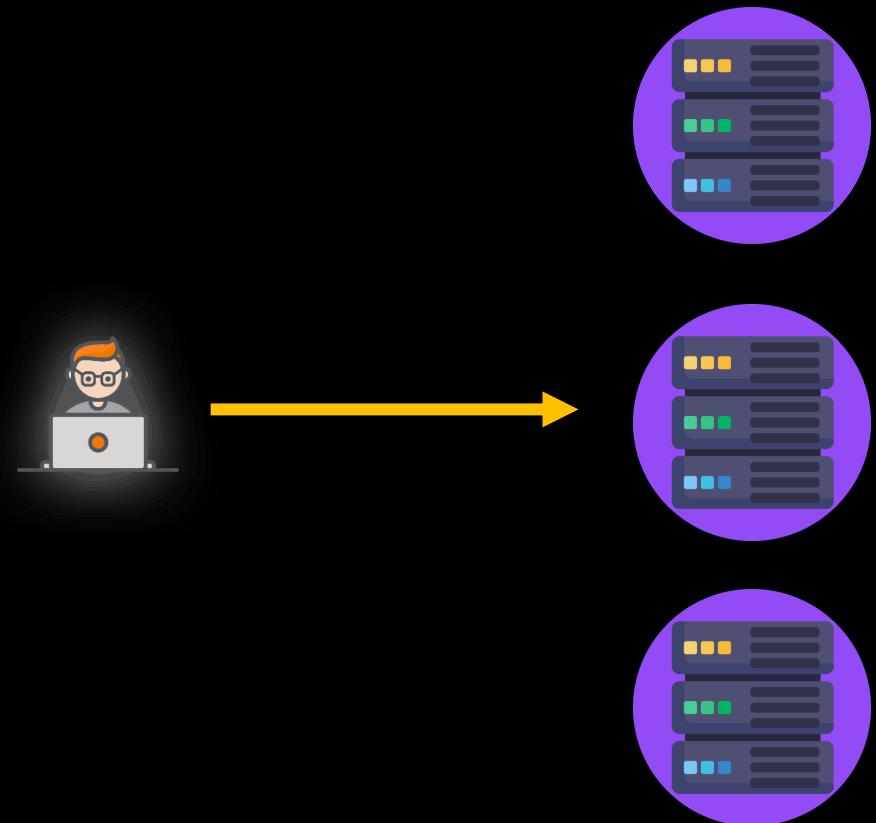


Any apps running on single
datacenter server

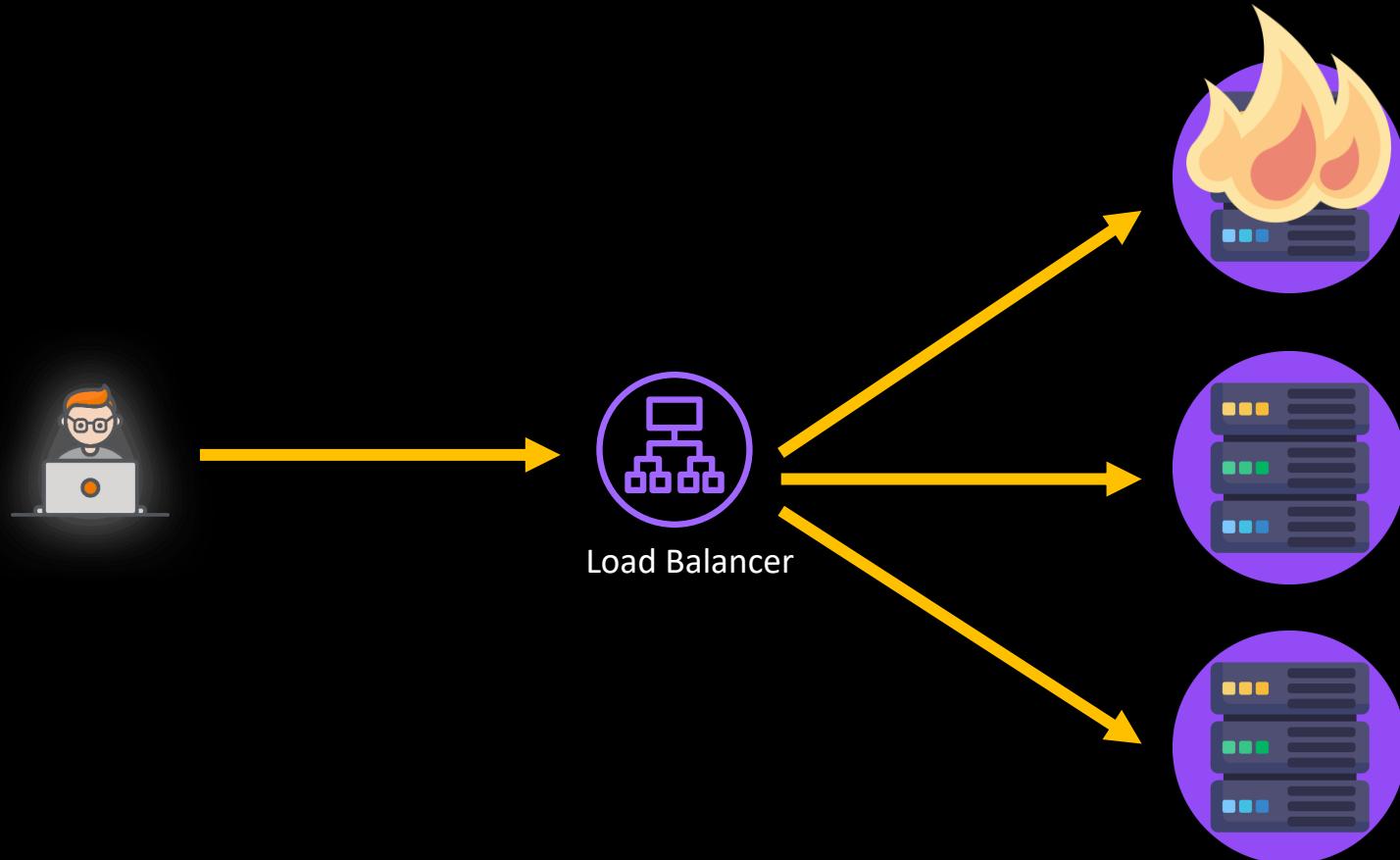
Distributed Systems



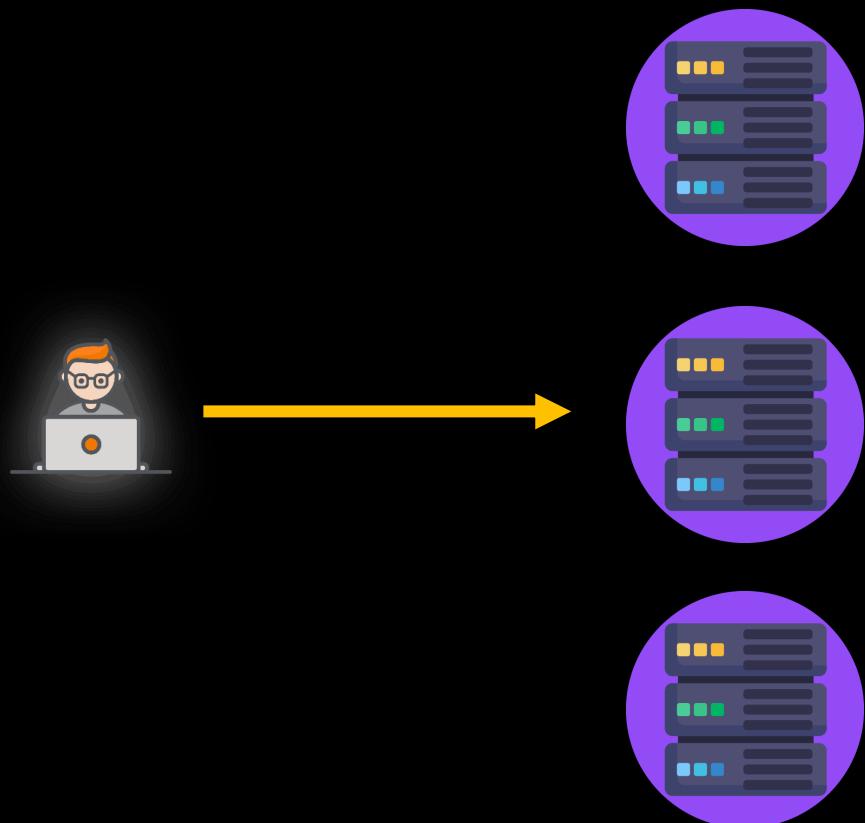
Distributed Systems



Distributed Systems



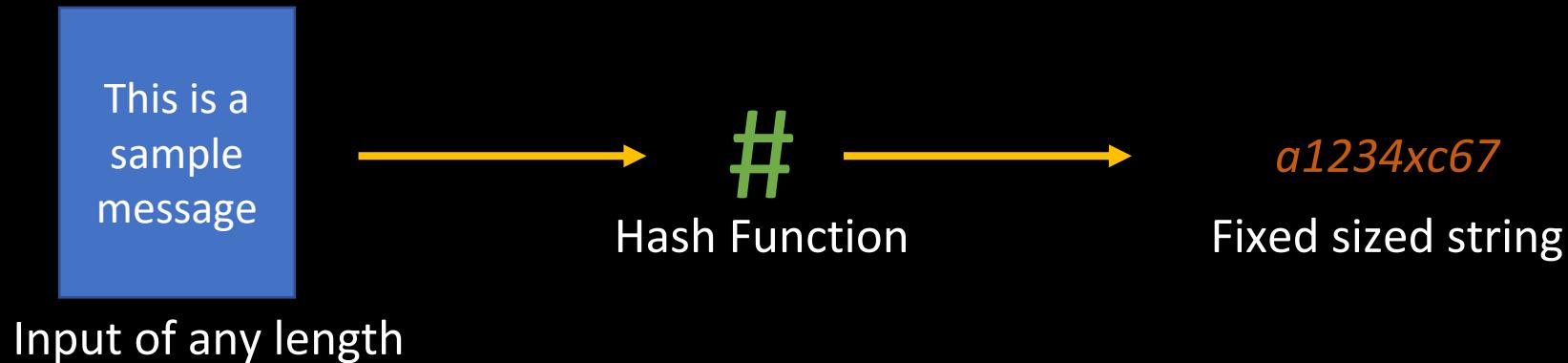
Distributed Systems



- System “distributed” on many servers
- Scale out by adding more servers
 - Horizontal scaling
- No single point of failure
- Most modern systems are distributed

Hashing

Hashing



Hashing

- Same input will always create same output
- Little change in input should create a vastly different output
- Hash function should be fast

More Importantly – How is hashing applied in system design??

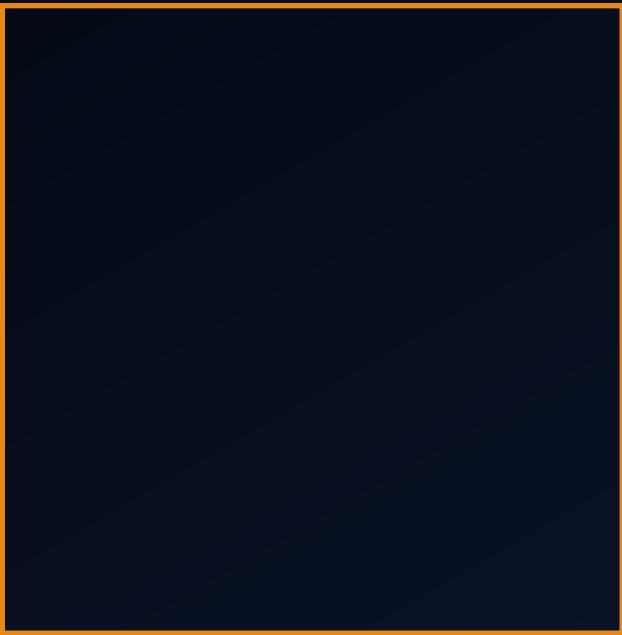
Table Partitions



DynamoDB
Table



Partition1

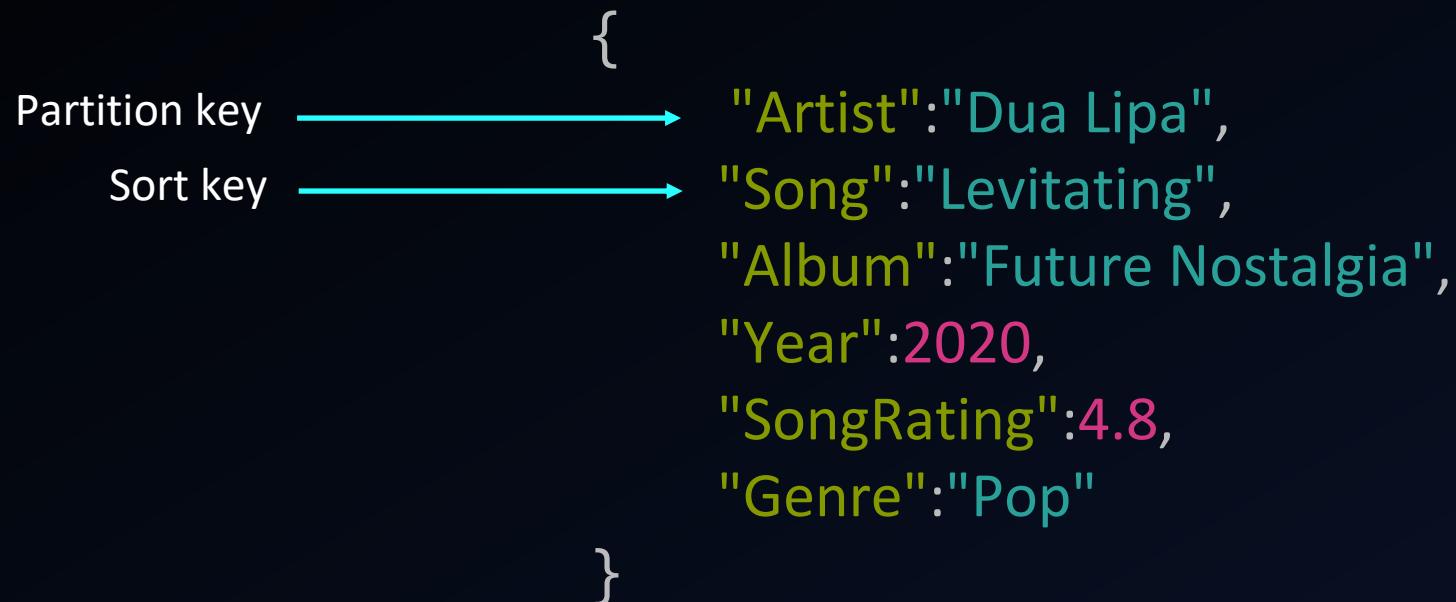


Partition2



Partition3

DynamoDB Primary Key



DynamoDB Partitions

```
{  
    "Artist":"Dua Lipa",  
    "Song":"Levitating",  
    "Album":"Future Nostalgia",  
    "Year":2020,  
    "SongRating":4.8,  
    "Genre":"Pop"  
}
```

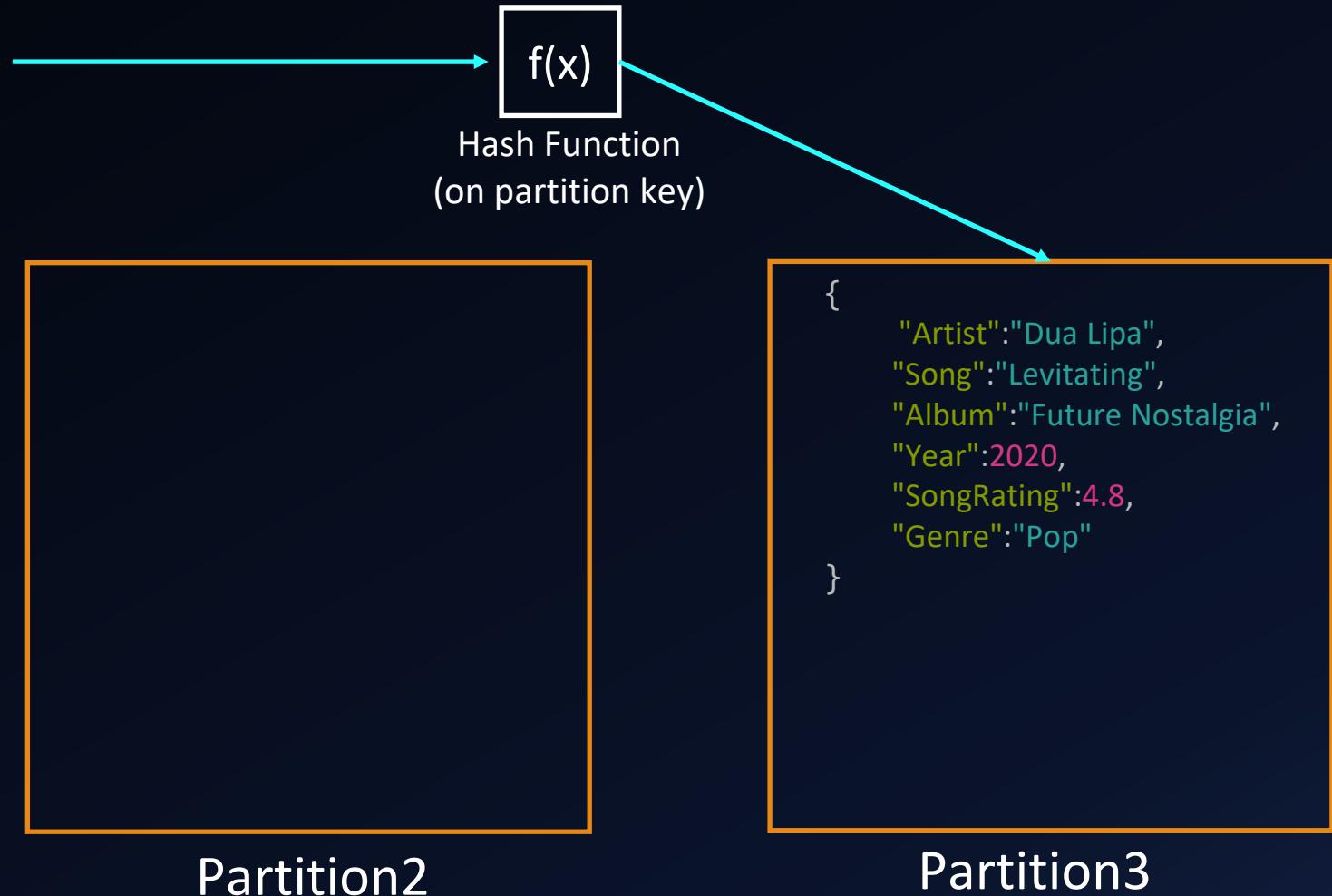


Partition1

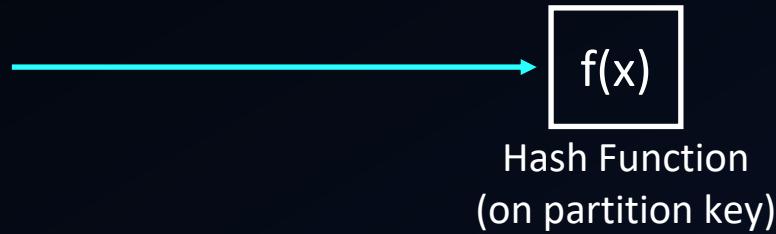
Partition2

Partition3

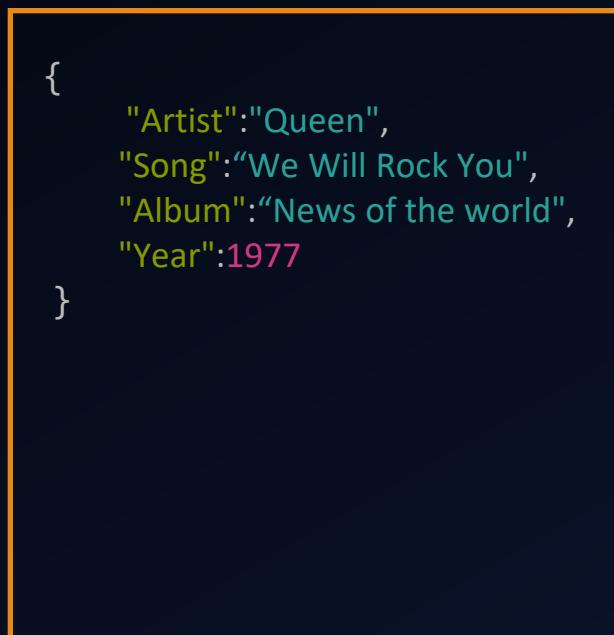
DynamoDB Partitions



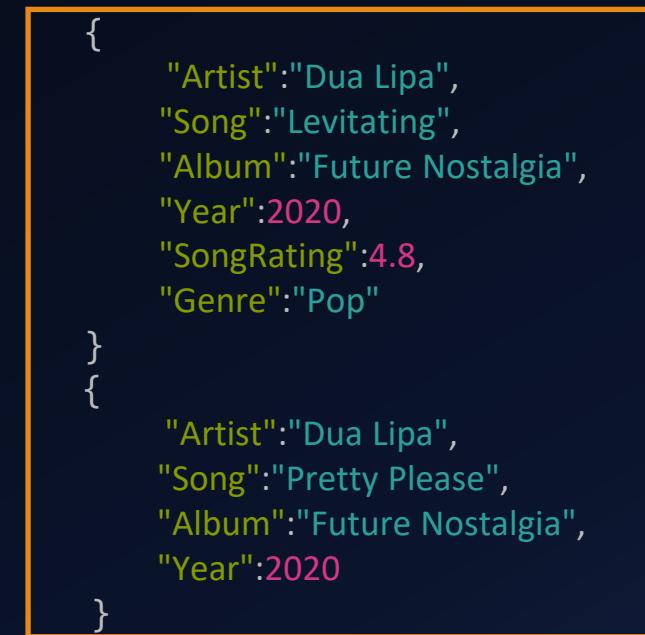
DynamoDB Partitions



Partition1

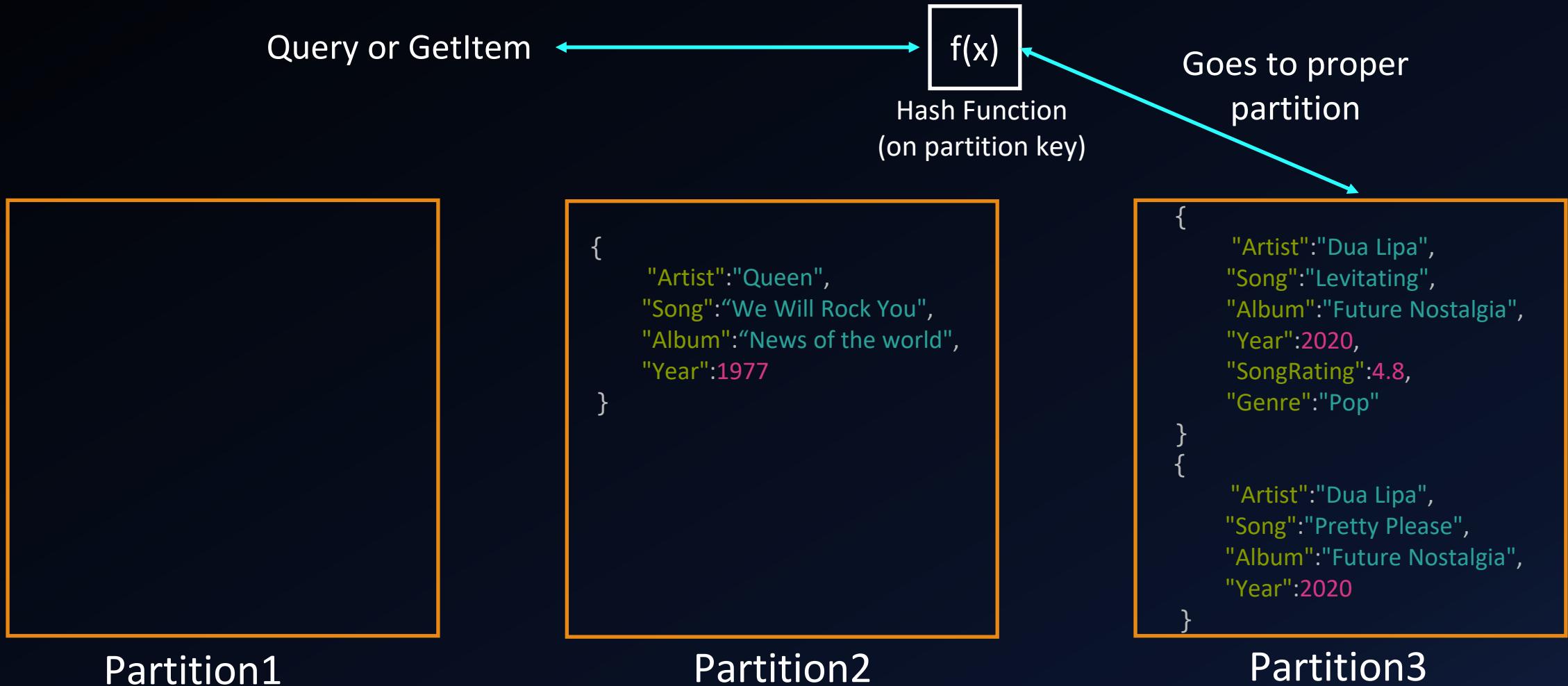


Partition2

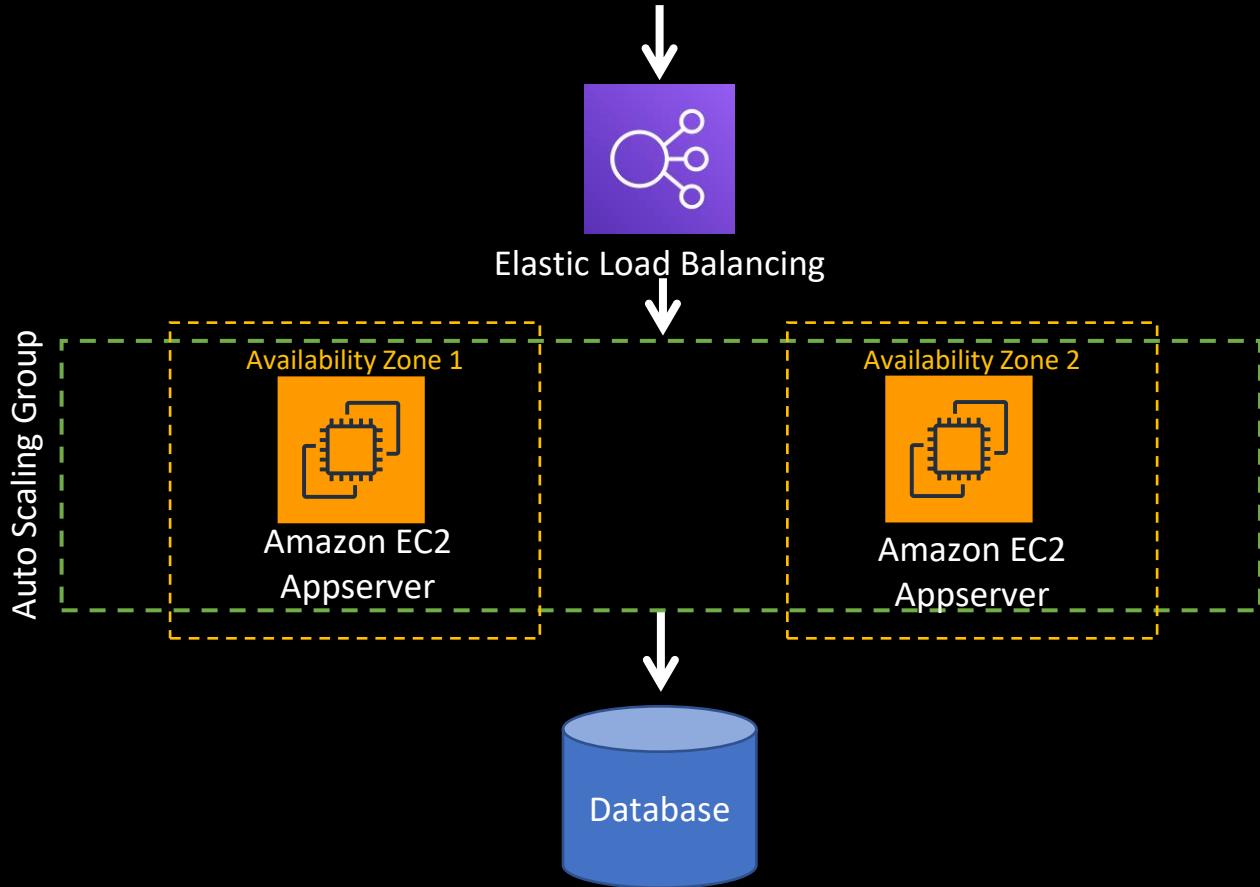


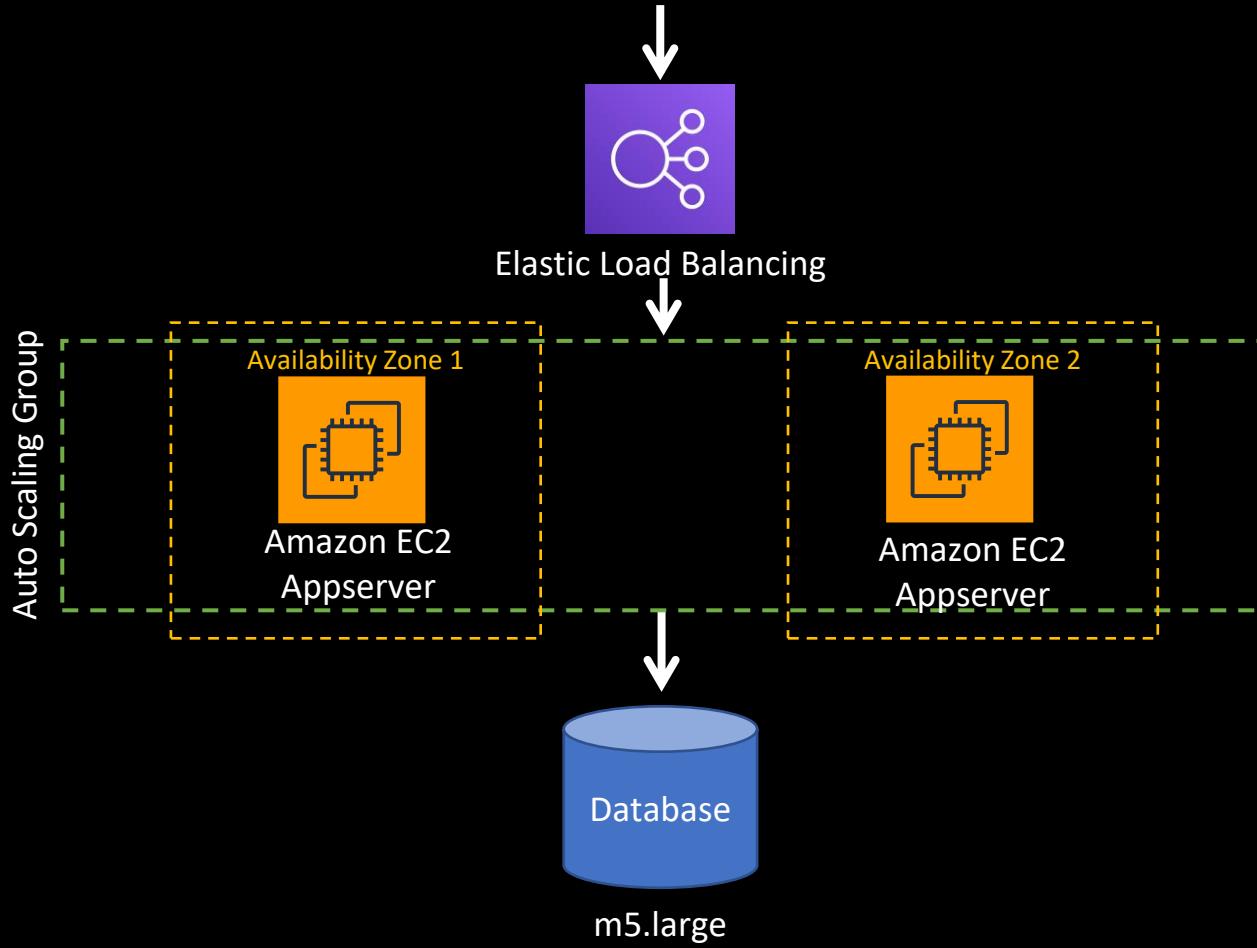
Partition3

DynamoDB Partitions

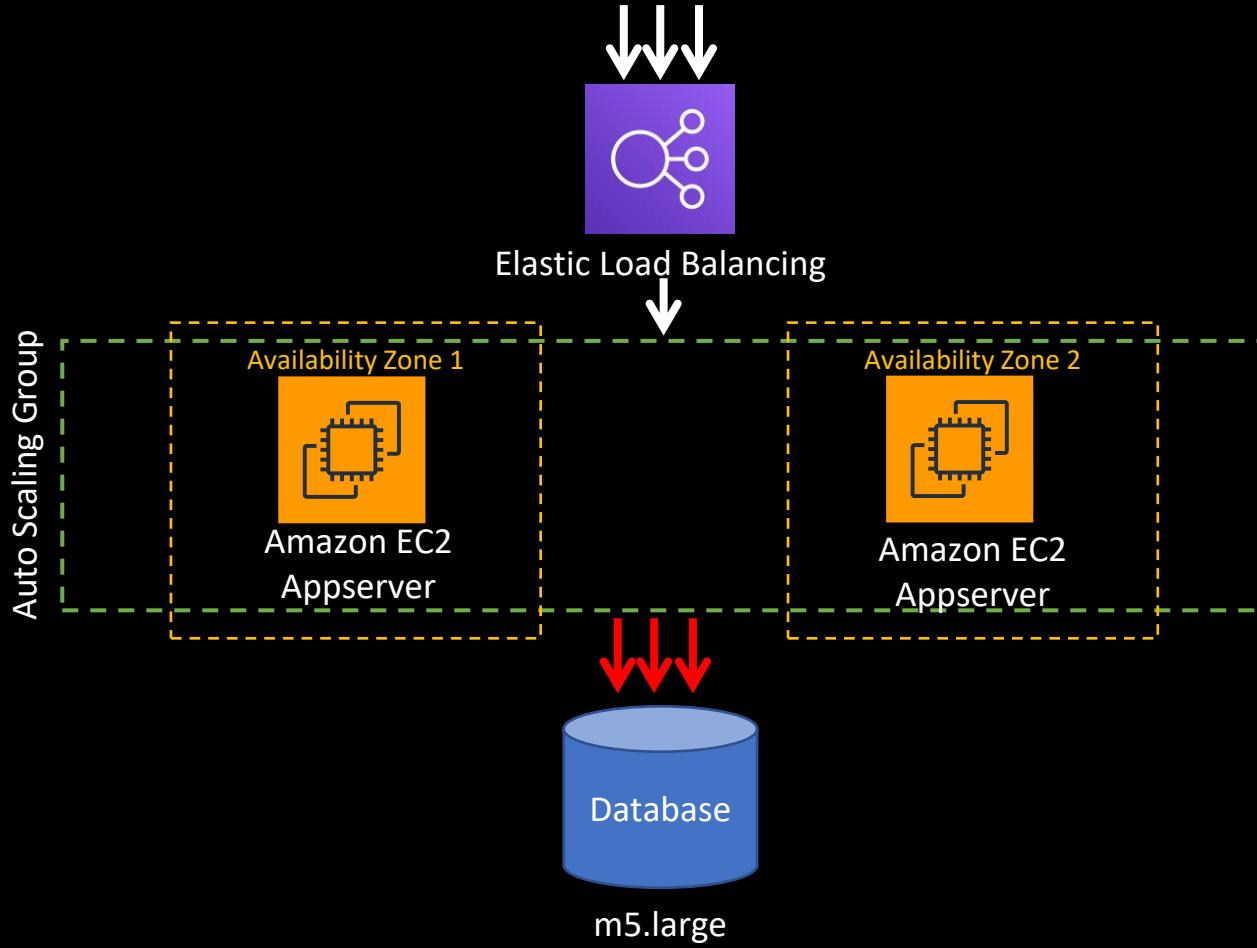


Database Sharding (Horizontal Partitioning)

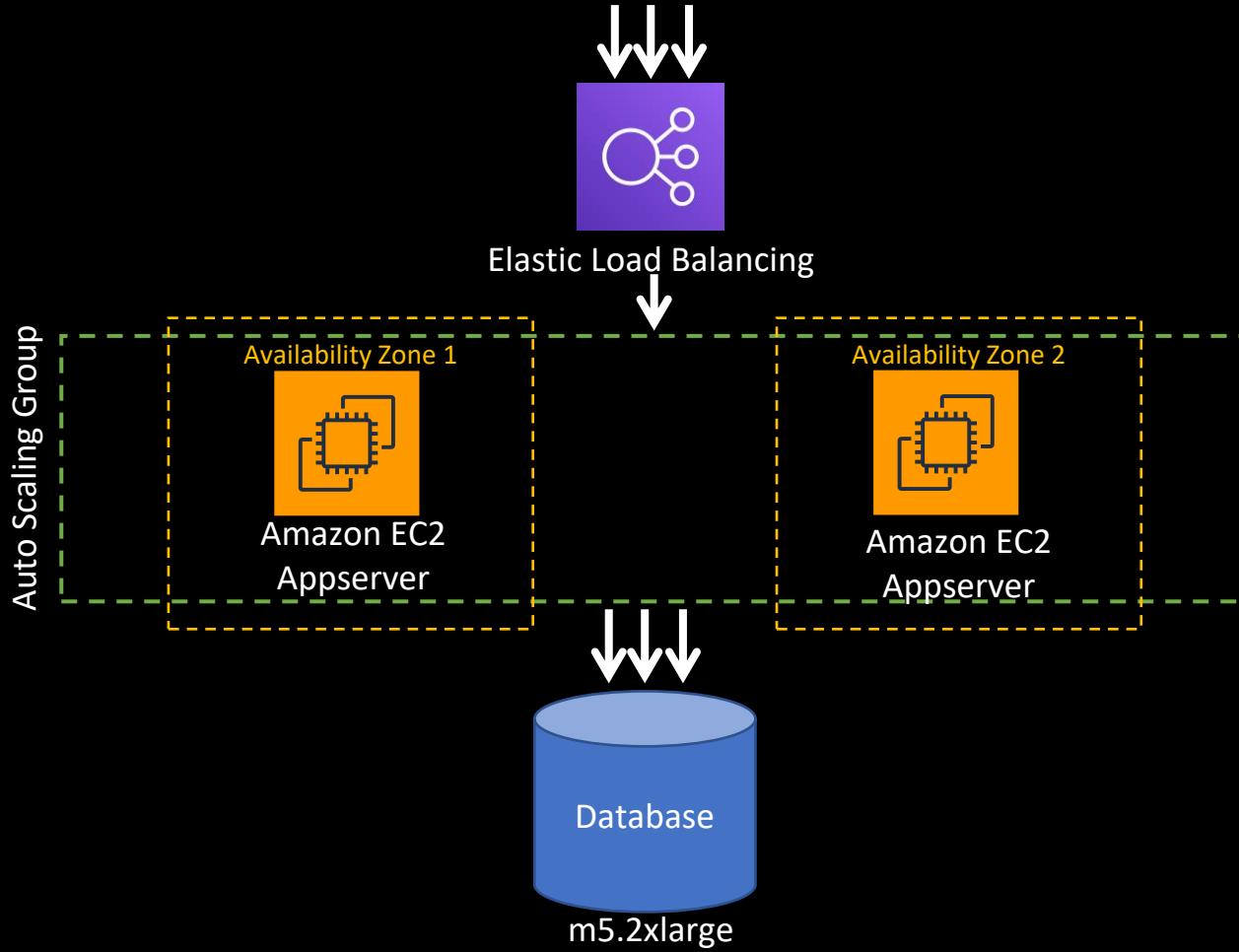




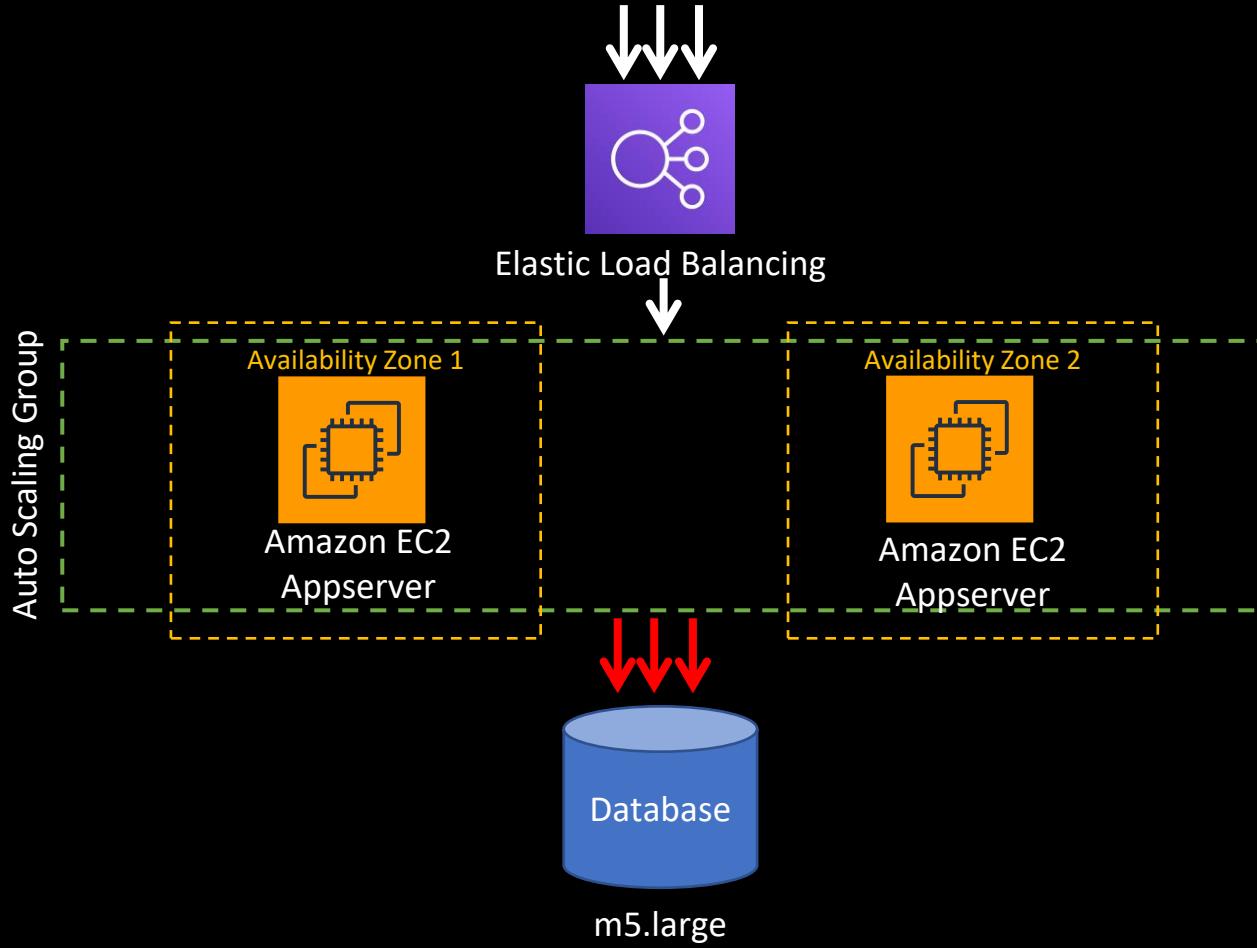
| ID | NAME | PRICE |
|----|-------------|-------|
| 1 | Alarm clock | 25 |
| 2 | Chair | 20 |
| 3 | Chocolate | 10 |
| 4 | TV | 400 |
| 5 | Couch | 100 |



| ID | NAME | PRICE |
|----|-------------|-------|
| 1 | Alarm clock | 25 |
| 2 | Chair | 20 |
| 3 | Chocolate | 10 |
| 4 | TV | 400 |
| 5 | Couch | 100 |



| ID | NAME | PRICE |
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Database Sharding

| ID | NAME | PRICE |
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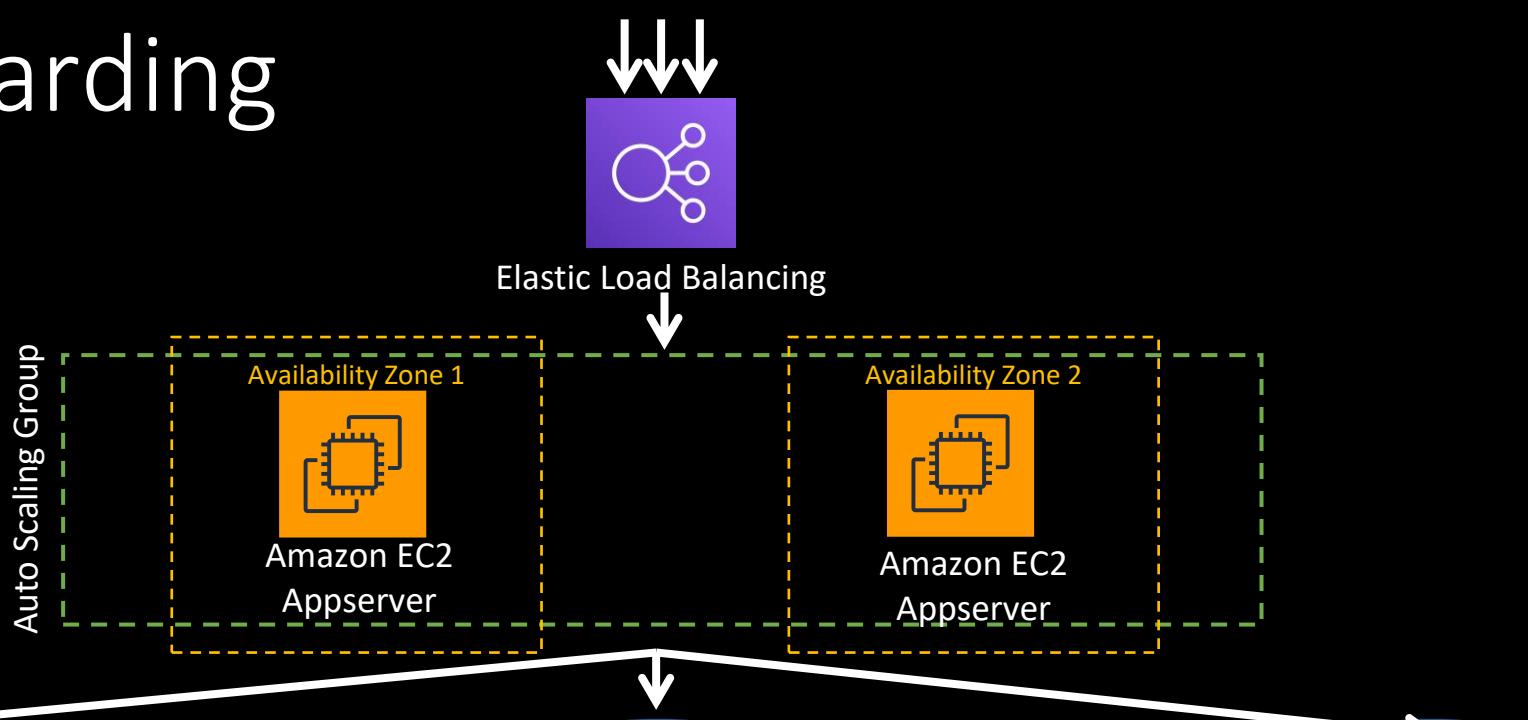


| ID | NAME | PRICE |
|----|-------------|-------|
| 1 | Alarm clock | 25 |
| 2 | Chair | 20 |
| | | |
| | | |
| | | |
| | | |

| ID | NAME | PRICE |
|----|-----------|-------|
| 3 | Chocolate | 10 |
| 4 | TV | 400 |
| | | |
| | | |
| | | |
| | | |

| ID | NAME | PRICE |
|----|-------|-------|
| 5 | Couch | 100 |
| | | |
| | | |
| | | |
| | | |

Database Sharding



m5.large



m5.large



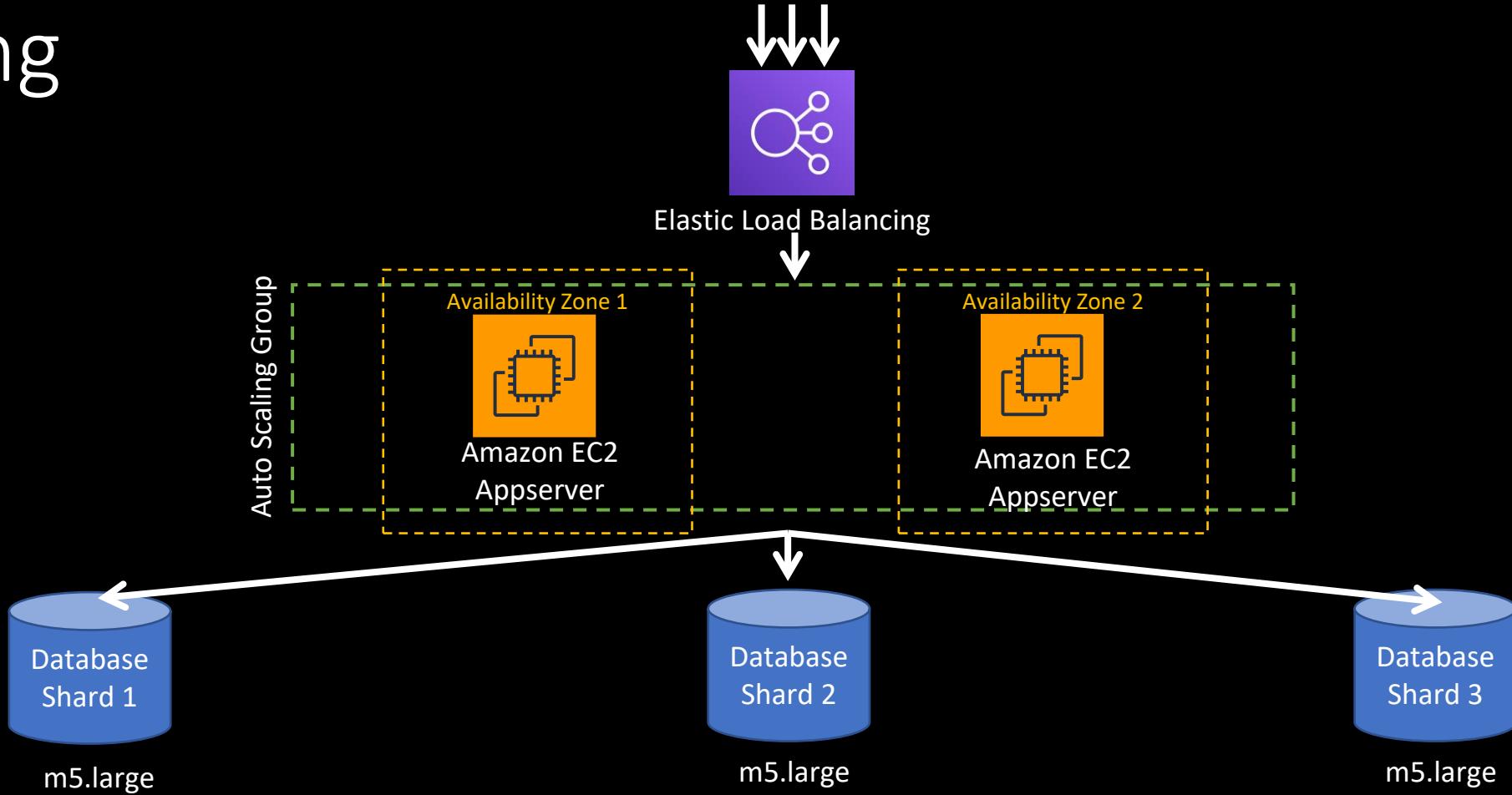
m5.large

| ID | NAME | PRICE |
|----|-------------|-------|
| 1 | Alarm clock | 25 |
| 2 | Chair | 20 |
| | | |
| | | |
| | | |

| ID | NAME | PRICE |
|----|-----------|-------|
| 3 | Chocolate | 10 |
| 4 | TV | 400 |
| | | |
| | | |
| | | |

| ID | NAME | PRICE |
|----|-------|-------|
| 5 | Couch | 100 |
| | | |
| | | |
| | | |

Hashing



| ID | NAME | PRICE |
|----|-------------|-------|
| 1 | Alarm clock | 25 |
| 2 | Chair | 20 |
| | | |
| | | |
| | | |
| | | |

| ID | NAME | PRICE |
|----|-----------|-------|
| 3 | Chocolate | 10 |
| 4 | TV | 400 |
| | | |
| | | |
| | | |
| | | |

| ID | NAME | PRICE |
|----|-------|-------|
| 5 | Couch | 100 |
| | | |
| | | |
| | | |
| | | |

Advantages

- Scaling horizontally supports distributed computing
- Faster query response times
- Limited blast radius during outage



m5.large

| ID | NAME | PRICE |
|----|-------------|-------|
| 1 | Alarm clock | 25 |
| 2 | Chair | 20 |
| | | |
| | | |
| | | |
| | | |



m5.large

| ID | NAME | PRICE |
|----|-----------|-------|
| 3 | Chocolate | 10 |
| 4 | TV | 400 |
| | | |
| | | |
| | | |
| | | |



m5.large

| ID | NAME | PRICE |
|----|-------|-------|
| 5 | Couch | 100 |
| | | |
| | | |
| | | |
| | | |

Disadvantages

- Unbalanced shards
- Resharding is painful
- Implementing sharding logic is an overhead



m5.large

| ID | NAME | PRICE |
|----|-------------|-------|
| 1 | Alarm clock | 25 |
| 2 | Chair | 20 |
| | | |
| | | |
| | | |
| | | |



m5.large

| ID | NAME | PRICE |
|----|-----------|-------|
| 3 | Chocolate | 10 |
| 4 | TV | 400 |
| | | |
| | | |
| | | |
| | | |



m5.large

| ID | NAME | PRICE |
|----|-------|-------|
| 5 | Couch | 100 |
| | | |
| | | |
| | | |
| | | |

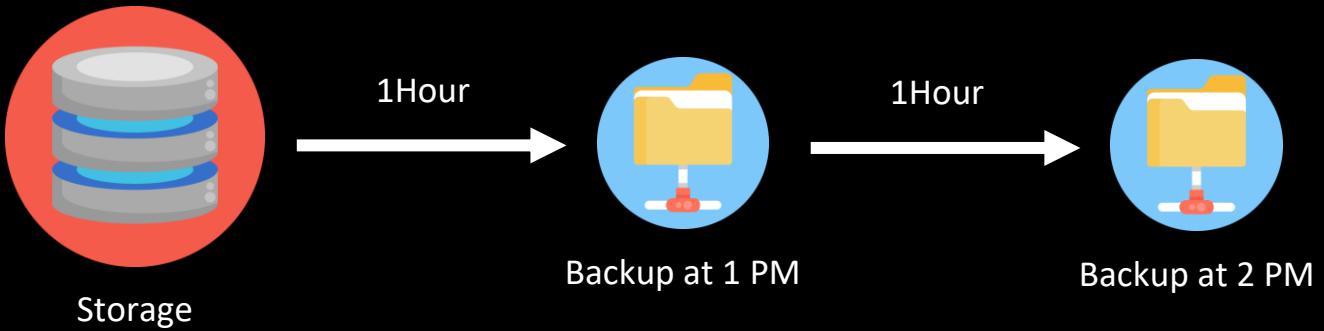
Disaster Recovery

RPO & RTO

How will you achieve DR?

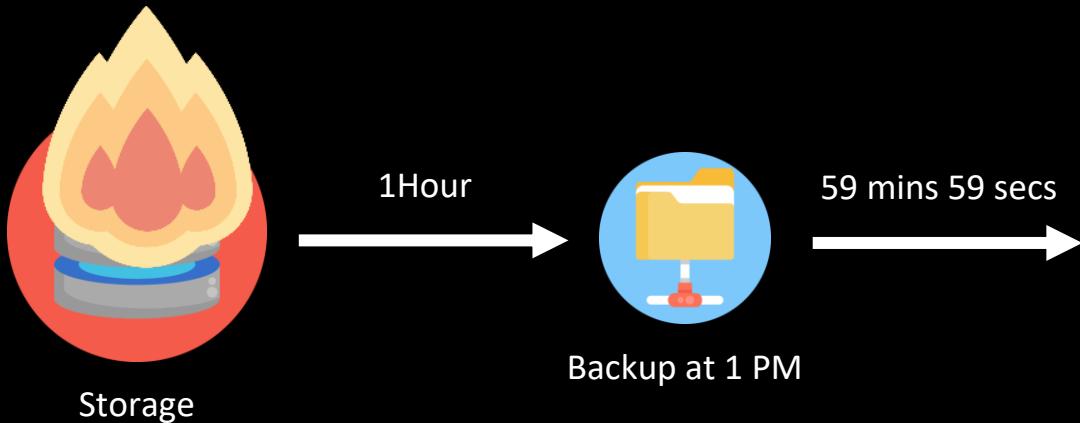
- There are multiple approaches to DR
 - Active-Active is NOT the only solution
- RPO/RTO plays a critical role

RPO



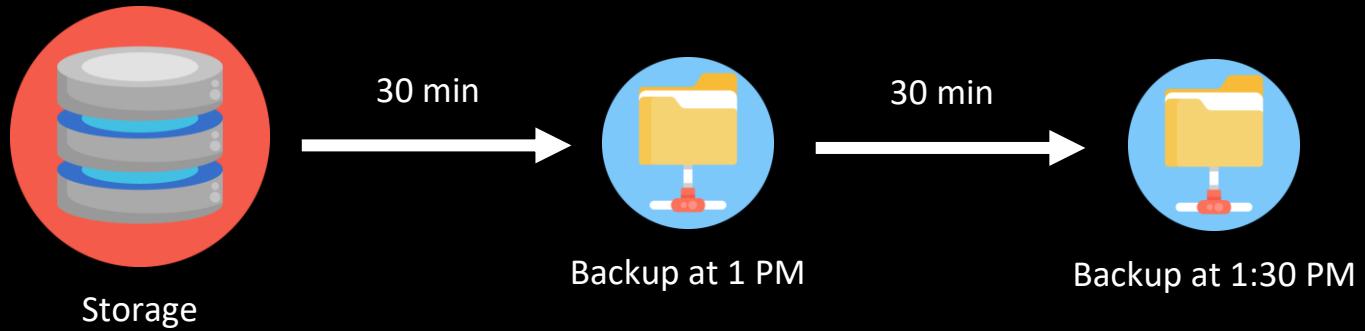
RPO

1:59:59 PM

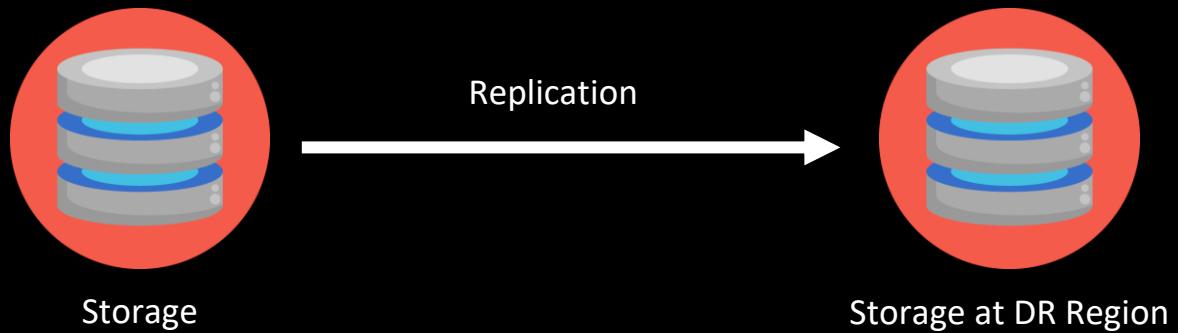


Recovery Point Objective = Amount of DATA that is allowed to be lost during a disaster measured in time
= 1 Hour for this case

How do you reduce RPO?



How about real time RPO?



RTO

1 PM



Application

Recovery Time Objective = Amount of TIME application
can be down during a disaster

RTO

2 PM



Application

Recovery Time Objective = Amount of TIME application
can be down during a disaster
= 1 Hour for this case

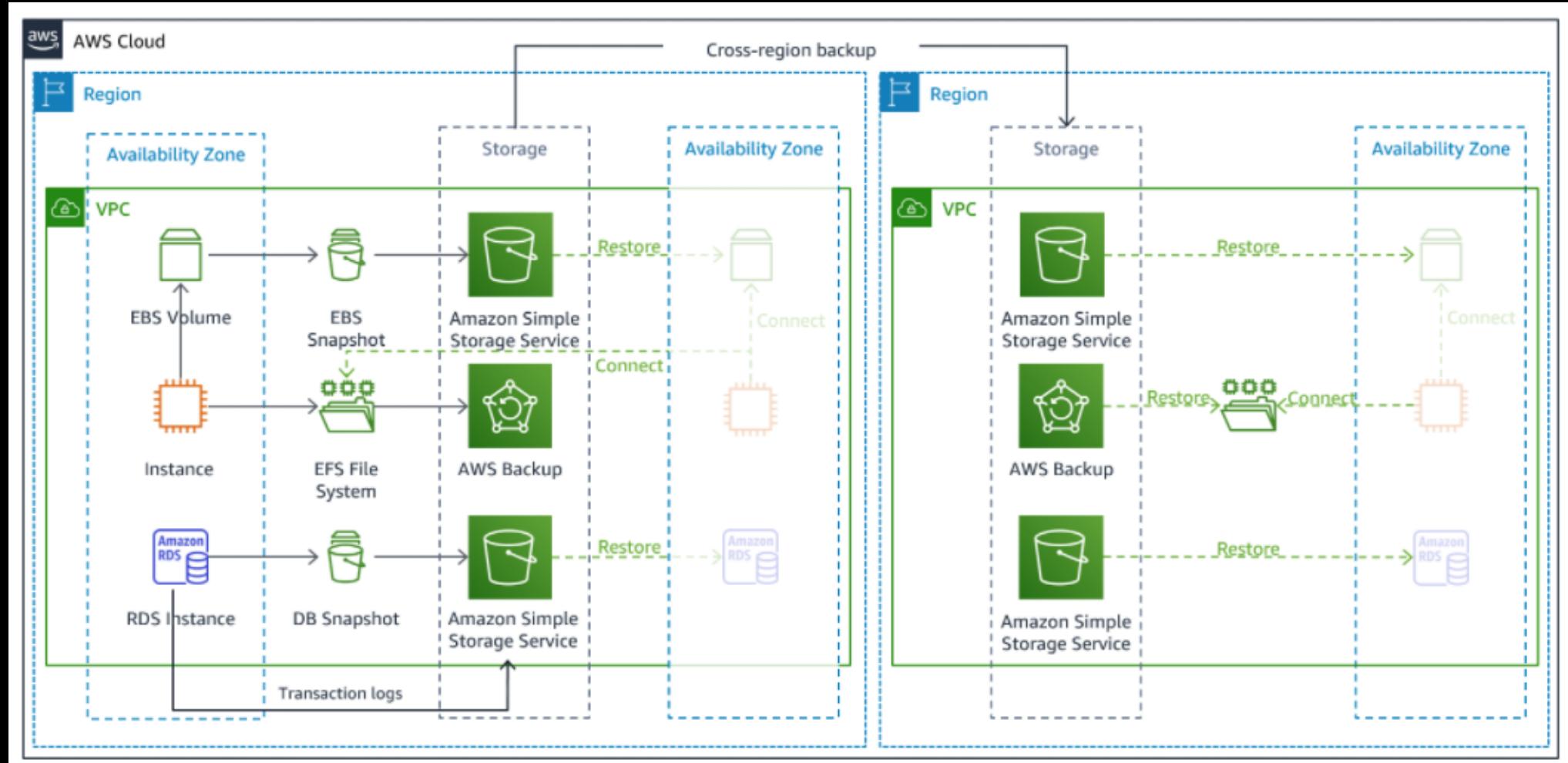
Disaster Recovery Options and Strategies

DR Strategies



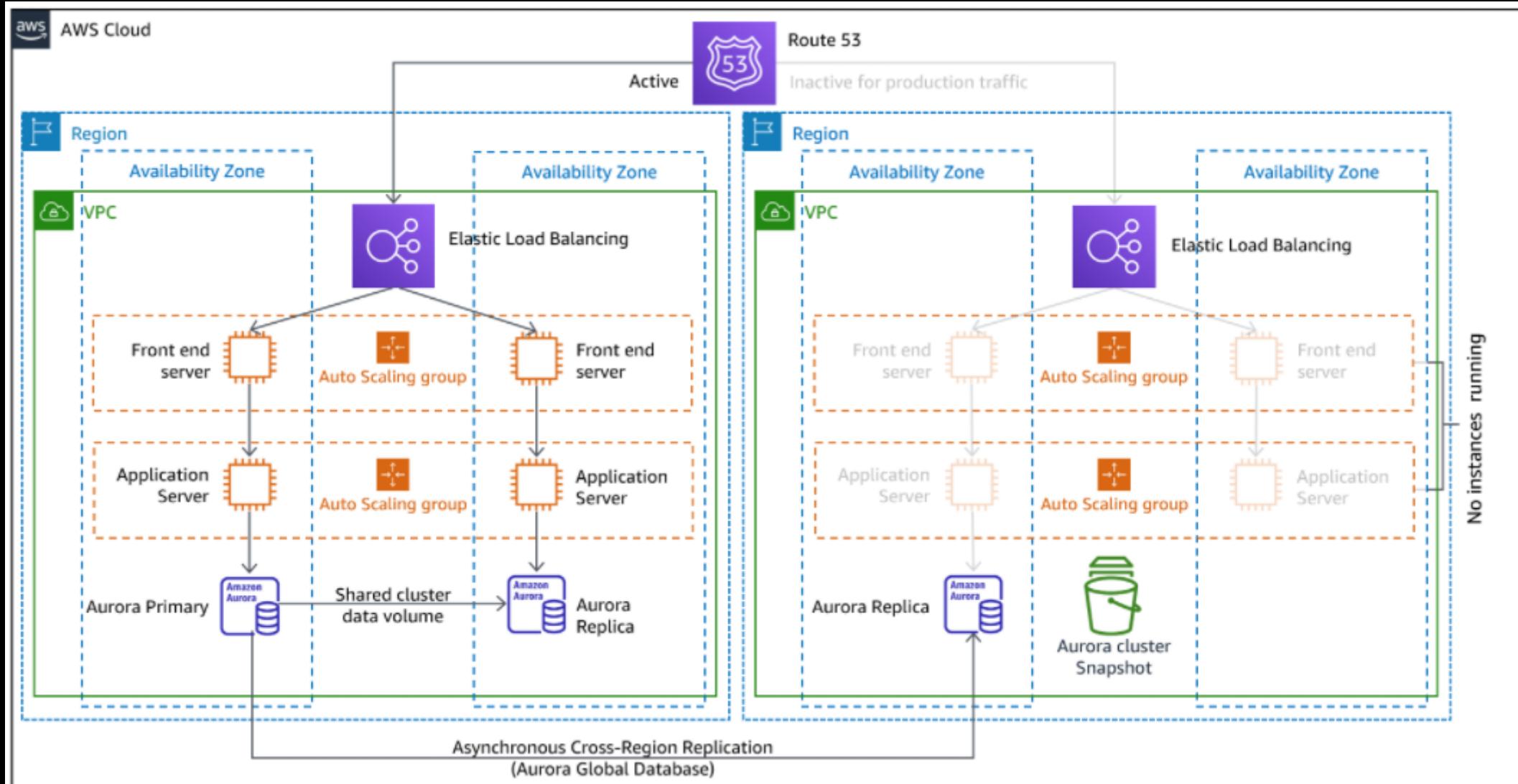
<https://docs.aws.amazon.com/whitepapers/latest/disaster-recovery-workloads-on-aws/disaster-recovery-options-in-the-cloud.html>

Backup Restore



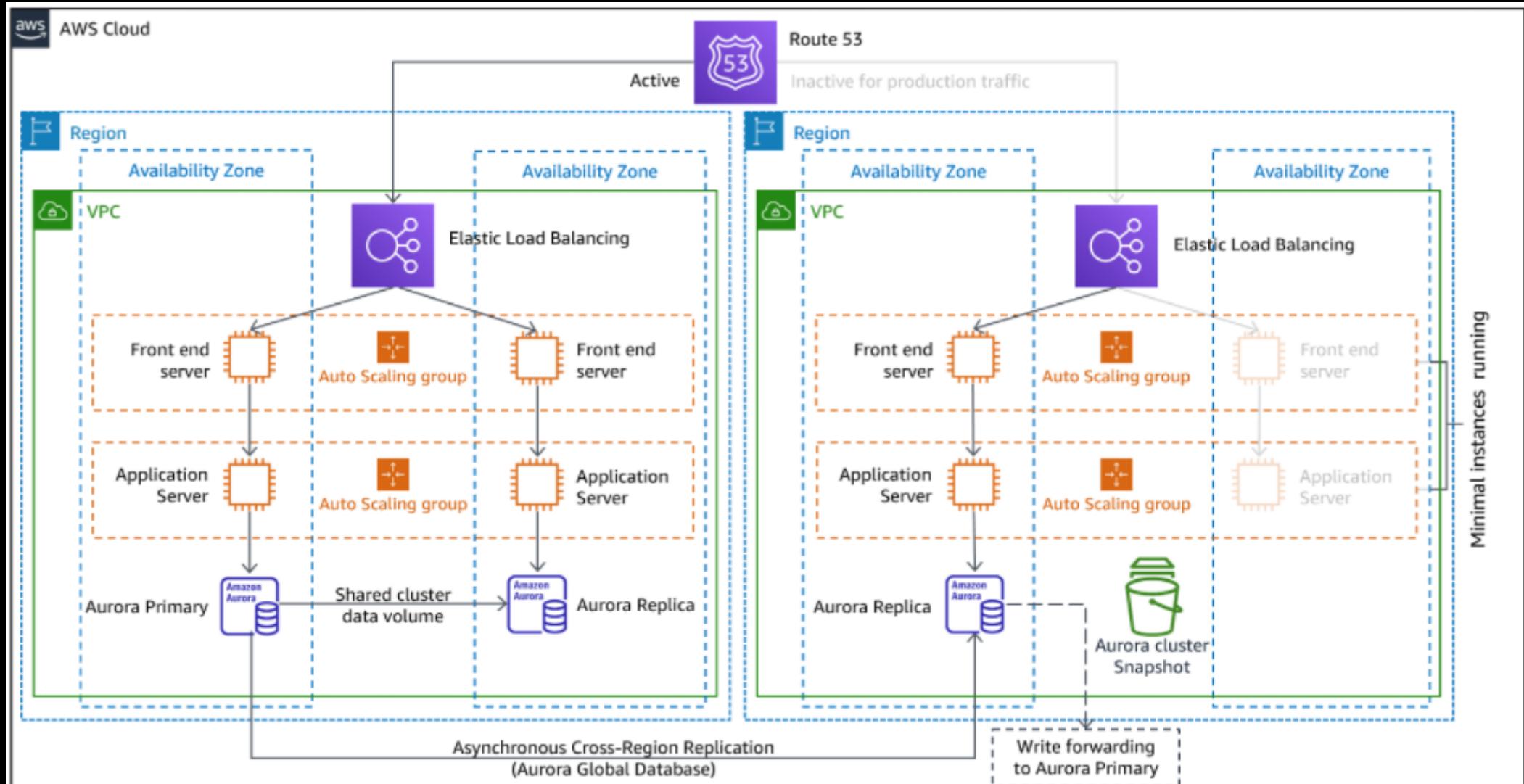
<https://docs.aws.amazon.com/whitepapers/latest/disaster-recovery-workloads-on-aws/disaster-recovery-options-in-the-cloud.html>

Pilot Light



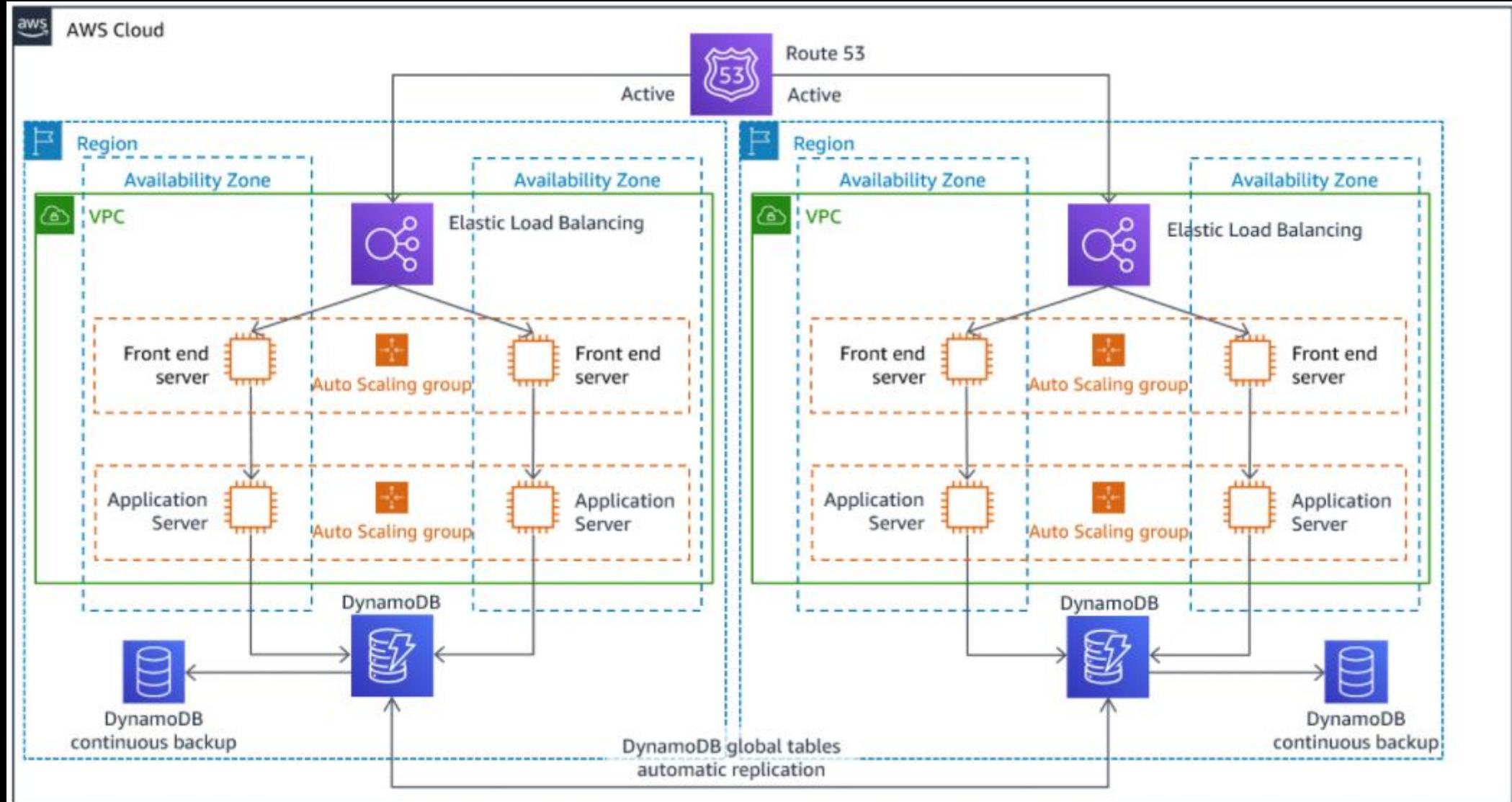
<https://docs.aws.amazon.com/whitepapers/latest/disaster-recovery-workloads-on-aws/disaster-recovery-options-in-the-cloud.html>

Warm Standby



<https://docs.aws.amazon.com/whitepapers/latest/disaster-recovery-workloads-on-aws/disaster-recovery-options-in-the-cloud.html>

Multi-site Active/Active



<https://docs.aws.amazon.com/whitepapers/latest/disaster-recovery-workloads-on-aws/disaster-recovery-options-in-the-cloud.html>

The Twelve-Factor App

I. Codebase

One codebase tracked in revision control, many deploys

II. Dependencies

Explicitly declare and isolate dependencies

III. Config

Store config in the environment

IV. Backing services

Treat backing services as attached resources

V. Build, release, run

Strictly separate build and run stages

VI. Processes

Execute the app as one or more stateless processes

VII. Port binding

Export services via port binding

VIII. Concurrency

Scale out via the process model

IX. Disposability

Maximize robustness with fast startup and graceful shutdown

X. Dev/prod parity

Keep development, staging, and production as similar as possible

XI. Logs

Treat logs as event streams

XII. Admin processes

Run admin/management tasks as one-off processes

- In 2012, developers at Heroku invented twelve-factor app to help build web apps
- Methodology used to make your app scalable, portable, resilient, faster recovery from disaster, minimize time and cost
- If you know cloud devops best practices, you are following most of these

I. Codebase

One codebase tracked in revision control, many deploys

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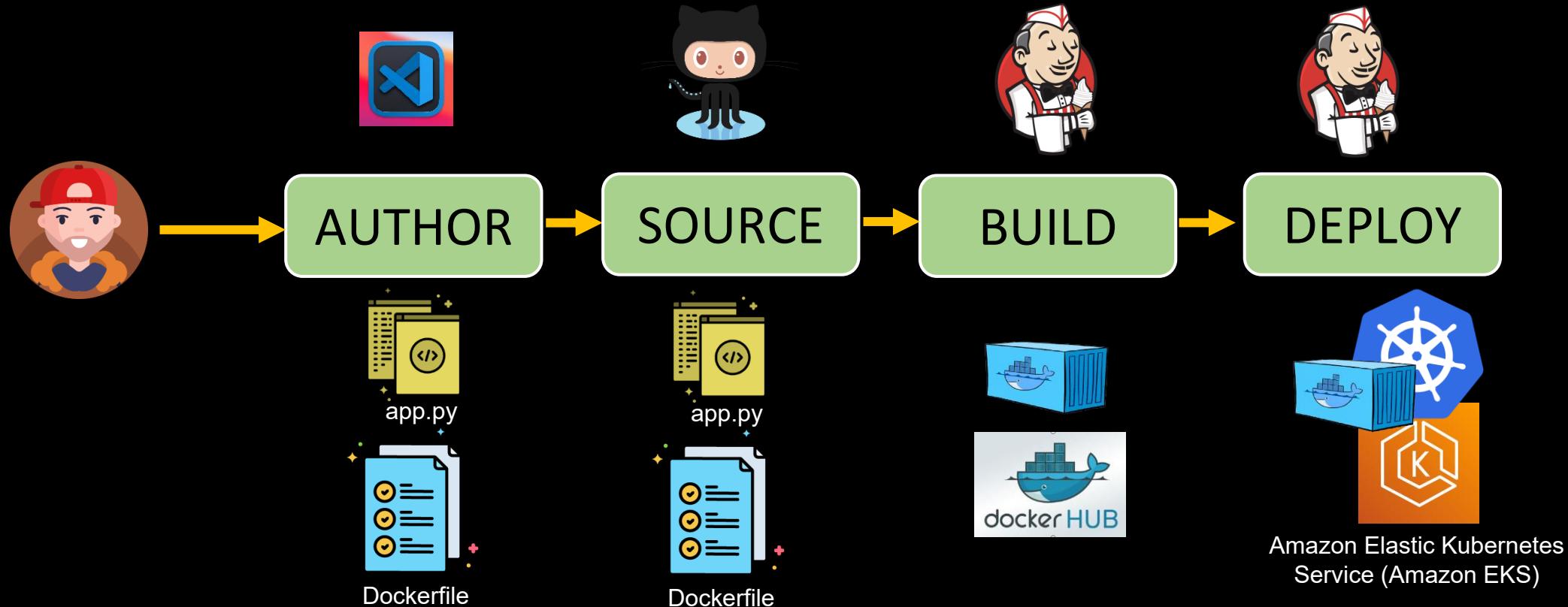
Treat logs as event streams

XII. Admin processes

Run admin/management tasks as one-off processes

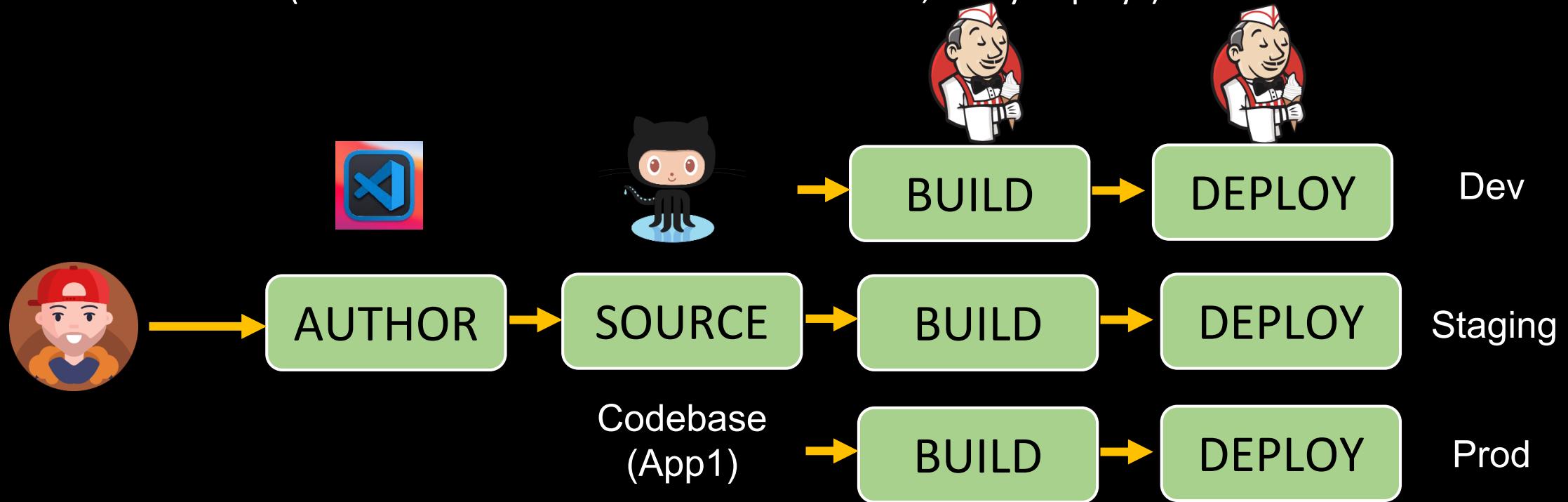
I. Codebase

(One codebase tracked in revision control, many deploys)



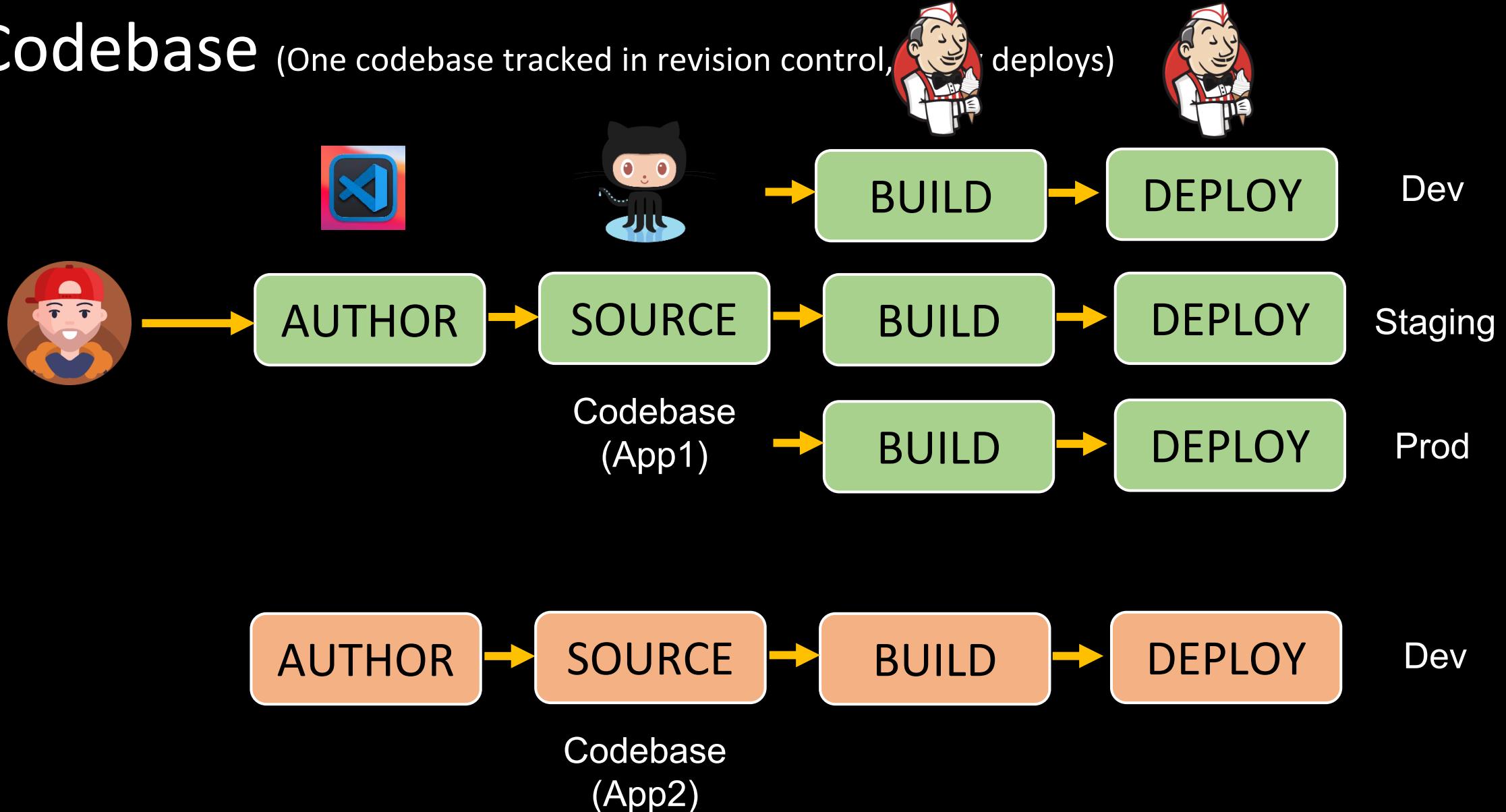
I. Codebase

(One codebase tracked in revision control, many deploys)



I. Codebase

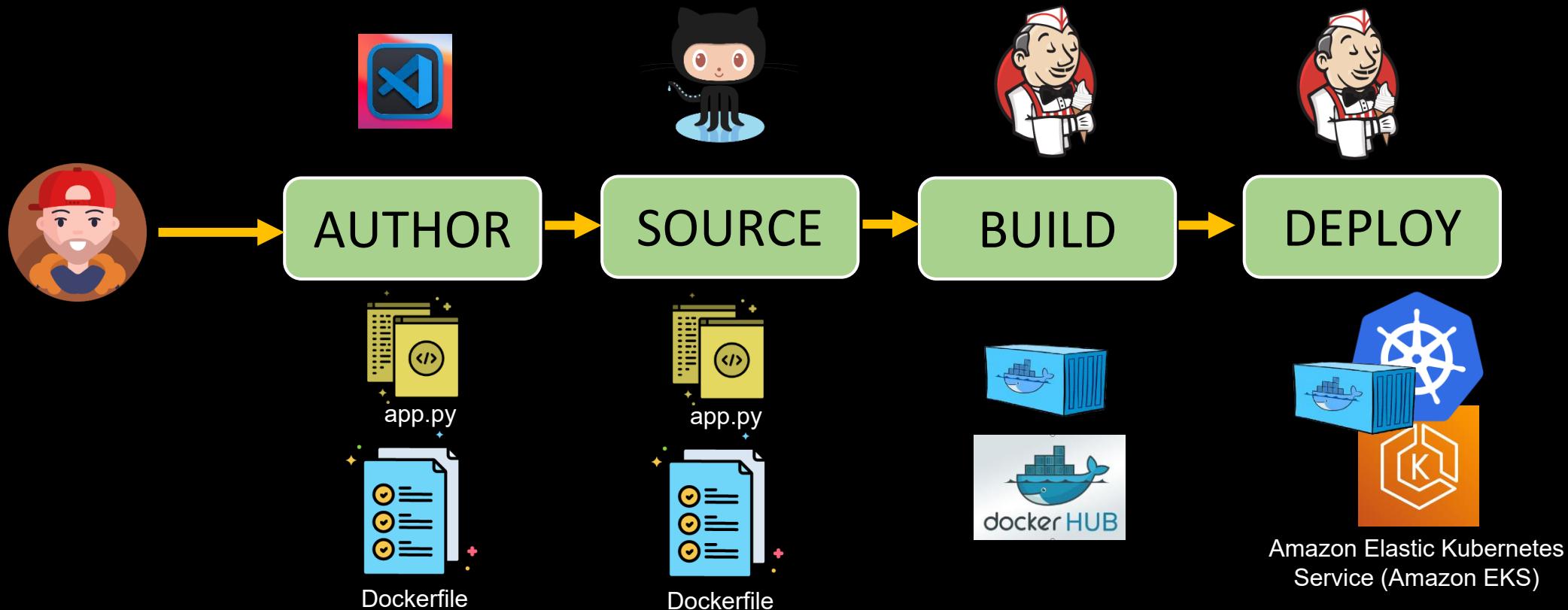
(One codebase tracked in revision control, shared by all environments)



Objective - Code can be deployed to any environment without any changes

- Remove any environment specific dependencies from the code
- Achieve maximum portability

II. Dependencies (Explicitly declare and isolate dependencies)



II. Dependencies (Explicitly declare and isolate dependencies)



AUTHOR



```
server.py > ...
1   from flask import Flask
2   app = Flask(__name__)
3
4   @app.route("/")
5   def hello():
6       return "Hello World!"
7
8   if __name__ == "__main__":
9       app.run(host='0.0.0.0')
```

```
requirements.txt
```

```
1   Flask==1.1.1
2
```

```
Dockerfile
```

```
# set base image (host OS)
1   FROM python:3.8
2
3
4   # set the working directory in the container
5   WORKDIR /code
6
7   # copy the dependencies file to the working directory
8   COPY requirements.txt .
9
10  # install dependencies
11  RUN pip install -r ./requirements.txt
12
13  # copy the content to the working directory
14  COPY server.py .
15
16  # command to run on container start
17  CMD [ "python", "./server.py" ]
```

II. Dependencies (Explicitly declare and isolate dependencies)

```
# server.py > ...
1  from flask import Flask
2  app = Flask(__name__)
3
4  @app.route("/")
5  def hello():
6      return "Hello World!"
7
8  if __name__ == "__main__":
9      app.run(host='0.0.0.0')
```

Dev

≡ requirements.txt

```
1  Flask==1.1.1
2  |
```

Python Virtual
environment
for Dev

Staging

≡ requirements.txt

```
1  Flask==2.1.1
2  |
```

Python Virtual
environment
for Staging

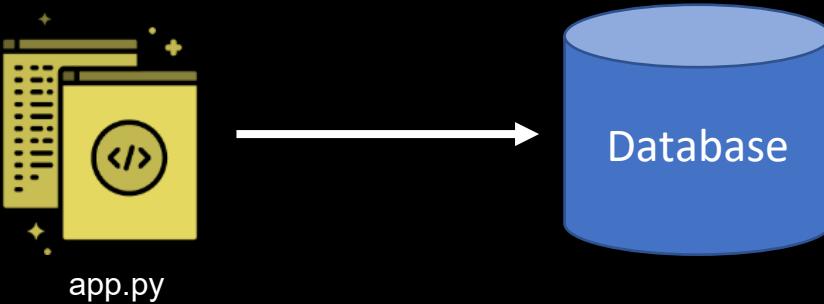
II. Dependencies (Explicitly declare and isolate dependencies)

A screenshot of a code editor interface, likely PyCharm, showing a tooltip for selecting an environment type. The tooltip lists two options: 'Venv' and 'Conda'. The 'Venv' option is highlighted, indicating it is the selected choice. The code editor shows a Python file named 'server.py' with the following content:

```
1  from flask import Flask
2  app = Flask(__name__)
3
4  @app.route("/")
5  def hello():
6      return "Hello World!"
7
8  if __name__ == "__main__":
9      app.run(host='0.0.0.0')
```

The code editor has a dark theme. A tooltip box is overlaid on the screen, containing the text 'Select an environment type' at the top, followed by two items: 'Venv Creates a `.venv` virtual environment in the current workspace' and 'Conda Creates a `.conda` Conda environment in the current workspace'. The 'Venv' item is highlighted with a dark gray background. Below the code editor, there is a vertical bar with the number '2' on it, and a blue button at the bottom right labeled 'Create Environment...'. The status bar at the bottom right shows 'PyCharm 2023.2'.

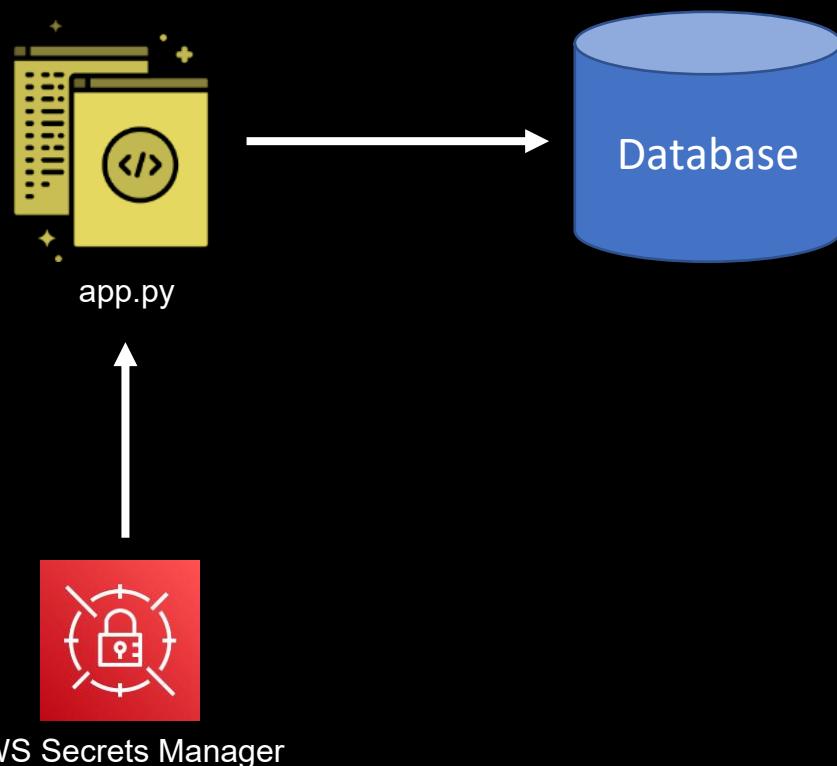
III. Config (Store config in the environment)



```
1 import pymysql
2
3 # Replace the following variables with your RDS instance credentials
4 host = "your_rds_host_endpoint"
5 port = 3306
6 dbname = "your_database_name"
7 user = "your_username"
8 password = "your_password"
9
10 # Connect to the RDS instance
11 try:
12     connection = pymysql.connect(
13         host=host,
14         port=port,
15         db=dbname,
16         user=user,
17         password=password
18     )
19     print("Connected to the RDS instance")
20
21 except pymysql.Error as error:
22     print(f"Error connecting to the RDS instance: {error}")
23
24 # Don't forget to close the connection when you're done
25 connection.close()
```

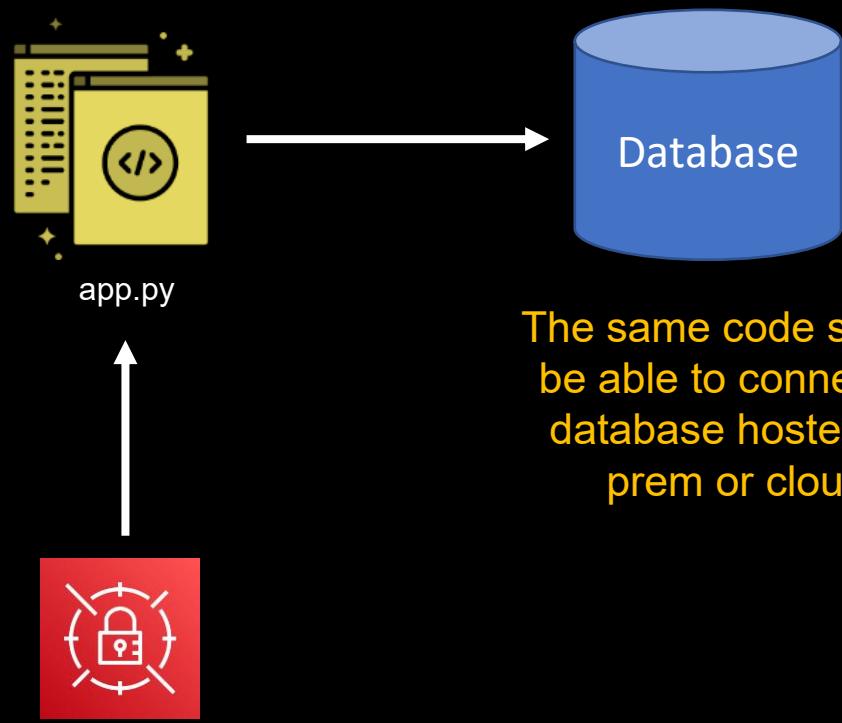
III. Config (Store config in the environment)

```
9  session = boto3.session.Session()
10 client = session.client(
11     service_name="secretsmanager",
12     region_name=region_name
13 )
14
15 response = client.get_secret_value(
16     SecretId=secret_name
17 )
18
19 secret_string = response["SecretString"]
20 secrets = json.loads(secret_string)
21
22 # Extract database credentials from the secrets
23 host = secrets["host"]
24 port = secrets["port"]
25 dbname = secrets["dbname"]
26 user = secrets["username"]
27 password = secrets["password"]
28
29 # Connect to the RDS instance
30 try:
31     connection = pymysql.connect(
32         host=host,
33         port=port,
34         db=dbname,
35         user=user,
36         password=password
37     )
```



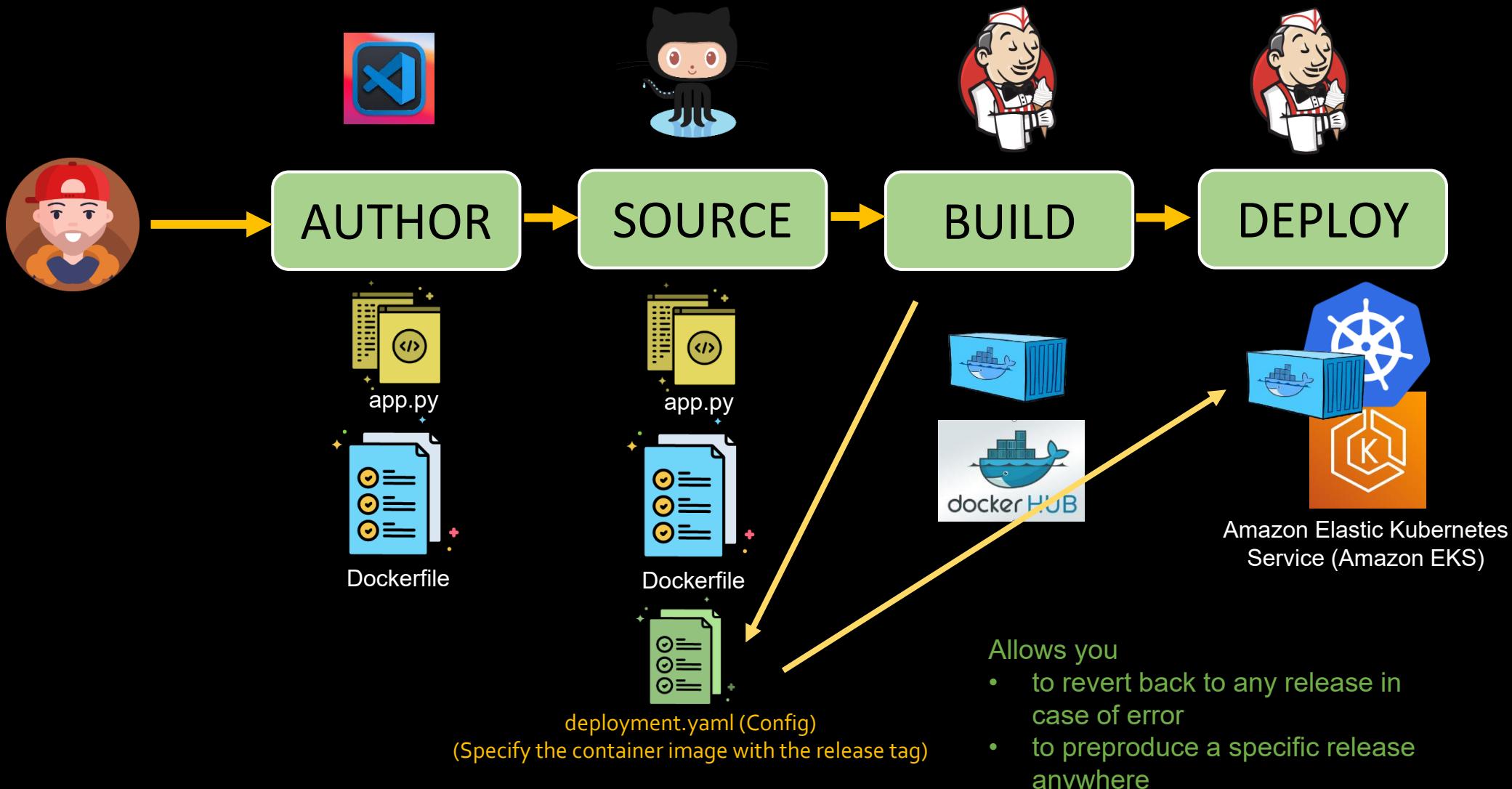
IV. Backing services (Treat backing services as attached resource)

```
9  session = boto3.session.Session()
10 client = session.client(
11     service_name="secretsmanager",
12     region_name=region_name
13 )
14
15 response = client.get_secret_value(
16     SecretId=secret_name
17 )
18
19 secret_string = response["SecretString"]
20 secrets = json.loads(secret_string)
21
22 # Extract database credentials from the secrets
23 host = secrets["host"]
24 port = secrets["port"]
25 dbname = secrets["dbname"]
26 user = secrets["username"]
27 password = secrets["password"]
28
29 # Connect to the RDS instance
30 try:
31     connection = pymysql.connect(
32         host=host,
33         port=port,
34         db=dbname,
35         user=user,
36         password=password
37     )
```



The same code should be able to connect to database hosted on prem or cloud

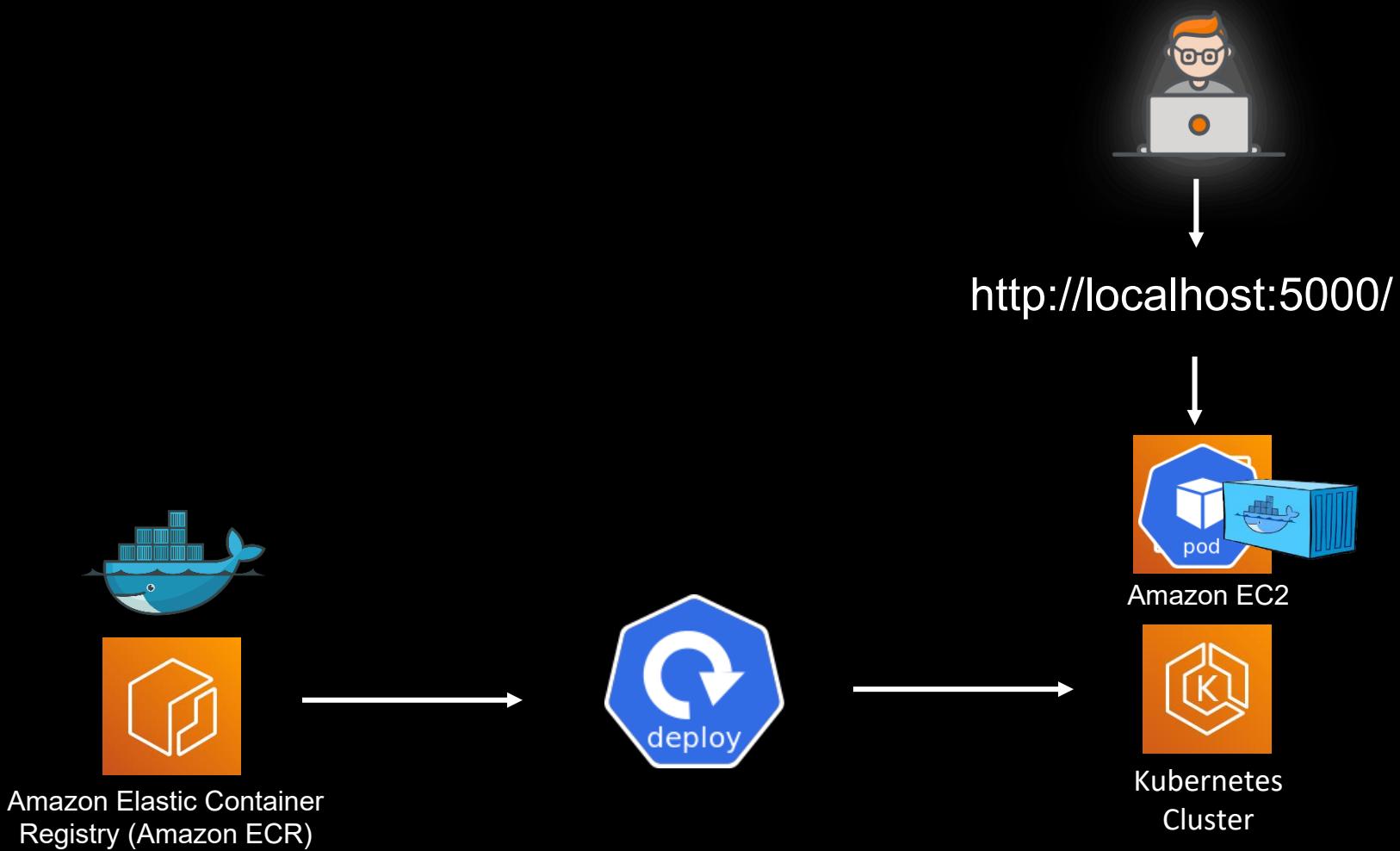
V. Build, release, run (Strictly separate build and run stages)



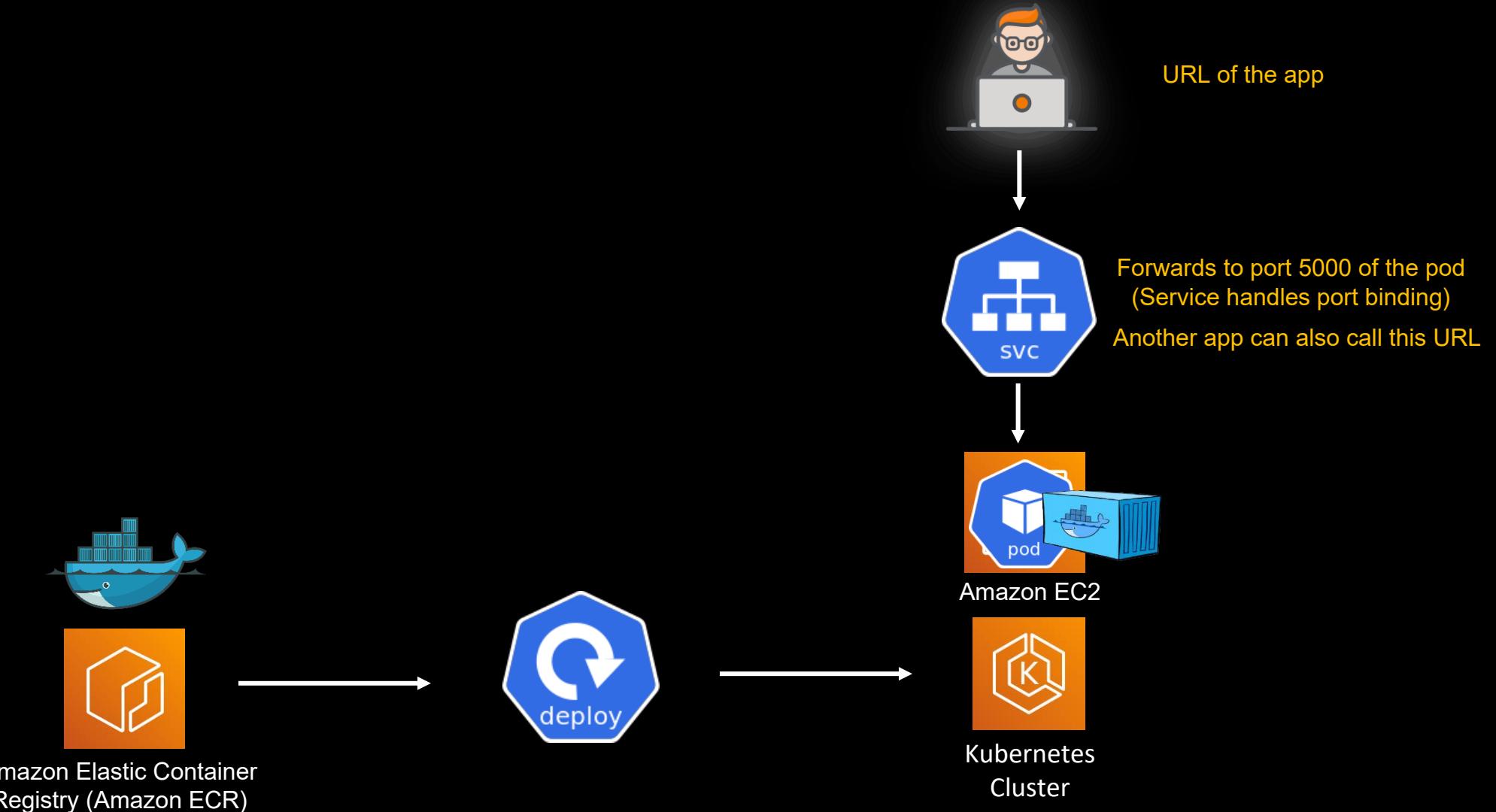
VI. Processes (Execute the app as one or more stateless processes)

- Process is minimum deployable unit of your app
 - One microservice backend code is one process
 - Multiple microservices working together for a functionality will be multiple processes
- Processes should be stateless and share-nothing
 - Any data that needs to persist should be stored in a stateful backing service like database
- Sticky sessions are in violation of twelve factor app

VII. Port binding (Execute services via port binding)



VII. Port binding (Execute services via port binding)

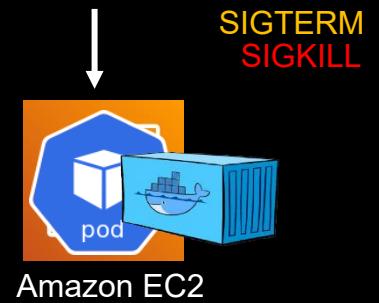


VIII. Concurrency (Scale out via process model)

- Till now we ensured all the processes (microservice/minimum deployable unit of the app) are portable
 - Moved dependencies/config/database-location out of code
 - Stateless
 - *We'll move logging dependencies out of the code as well (Number XI)*
- Scale the processes using horizontal scaling

IX. Disposability (Maximize robustness with fast startup and graceful shutdown)

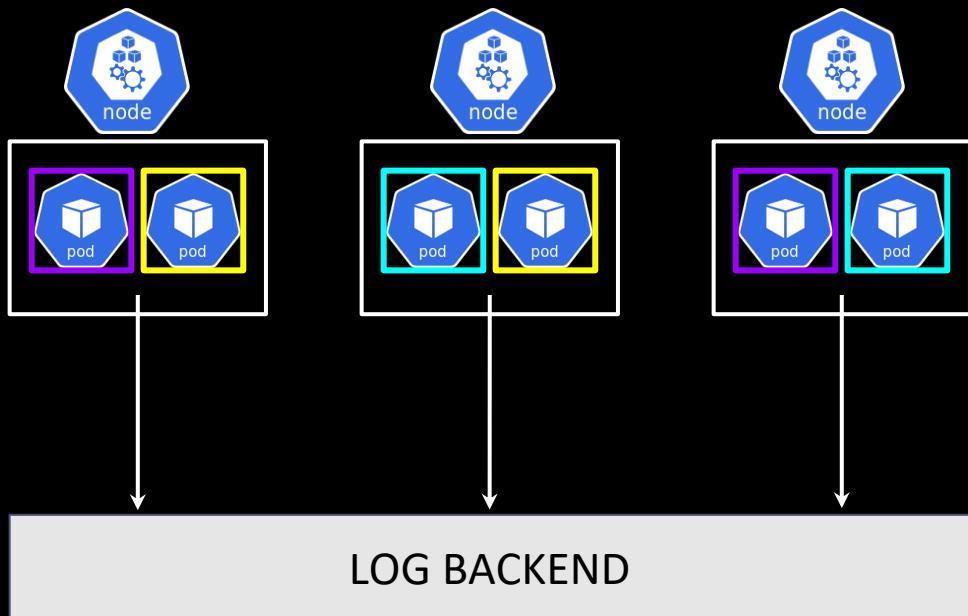
- Processes are disposable, meaning they can be started or stopped at a moment's notice
- Graceful shutdown
 - Stop accepting new requests
 - Allow current requests to finish
 - Exit
- In case graceful shutdown not possible
 - Return jobs to the queue



X. Dev/prod parity (Keep development, staging, and production as similar as possible)

- Pre DevOps/Containers era – substantial gap between dev and prod
 - Time gap – longer time to go to prod
 - Personnel gap – separation between dev and ops
 - Tools gap – different tools used in dev and prod
- Utilize DevOps practices
 - Continuous deployment
 - Same tools in dev and prod
 - Containerization solves this
 - Use same backing service in dev and prod (Cost efficient cloud services solve this)

XI. Logs (Treat logs as event streams)



Code sending logs directly to Splunk

```
hec_url = "https://your_splunk_instance:8088/services/collector"
hec_token = "your_hec_token"

# Define your log event
event = {
    "time": "your_event_timestamp",
    "sourcetype": "your_sourcetype",
    "event": {
        "message": "This is a log message",
        "severity": "info",
        "custom_field": "custom_value"
    }
}

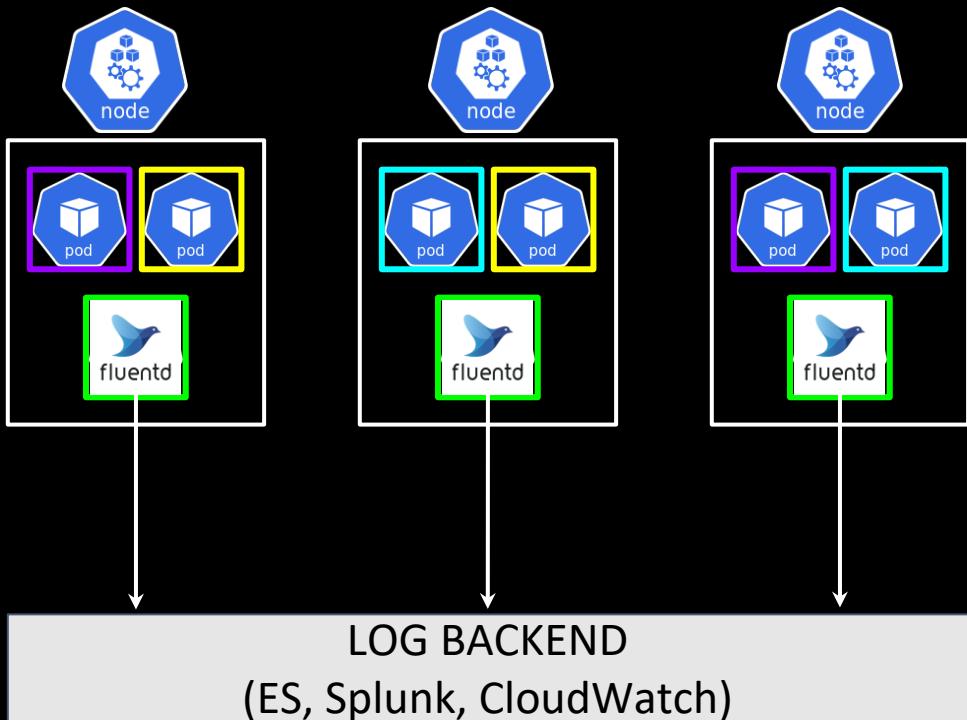
# Set headers for the POST request
headers = {
    "Content-Type": "application/json",
    "Authorization": f"Splunk {hec_token}"
}

# Send the log event to Splunk
try:
    response = requests.post(hec_url, headers=headers, data=json.dumps(event), verify=False)
```

Challenges

- Code need to be changed between environments (dev, stage, prod)
- Code need to be changed for changing logging backend
- Tightly coupled log integration
 - Both compute and logging platform need to scale at same rate

XI. Logs (Treat logs as event streams)



= Logging agent running as daemon, reading logs from stdout and sending to logging backend



Writing logs to stdout

```
import json

# Define your log event
event = {
    "time": "your_event_timestamp",
    "sourcetype": "your_sourcetype",
    "event": {
        "message": "This is a log message",
        "severity": "info",
        "custom_field": "custom_value"
    }
}

# Convert the event to a JSON string
event_json = json.dumps(event)

# Write the log event to stdout
print(event_json)
```

XII. Admin processes (Run admin/management tasks as one-off processes)

- At times, one off admin processes needed to be run
 - Update database values
 - Run one time scripts
- Admin processes should:
 - Run in the identical environment of the app
 - Use same codebase
 - Ship with the application
 - Create separate run, build, release with admin code
 - Should produce logs

- Used to make your app scalable, resilient, faster recovery from disaster, faster time to market
- If you know cloud best practices, you are following most of these
- Do I need to remember all of these for interview?
 - Are all these still relevant?

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Run admin/management tasks as one-off processes

12 Factor App Interview Q/A

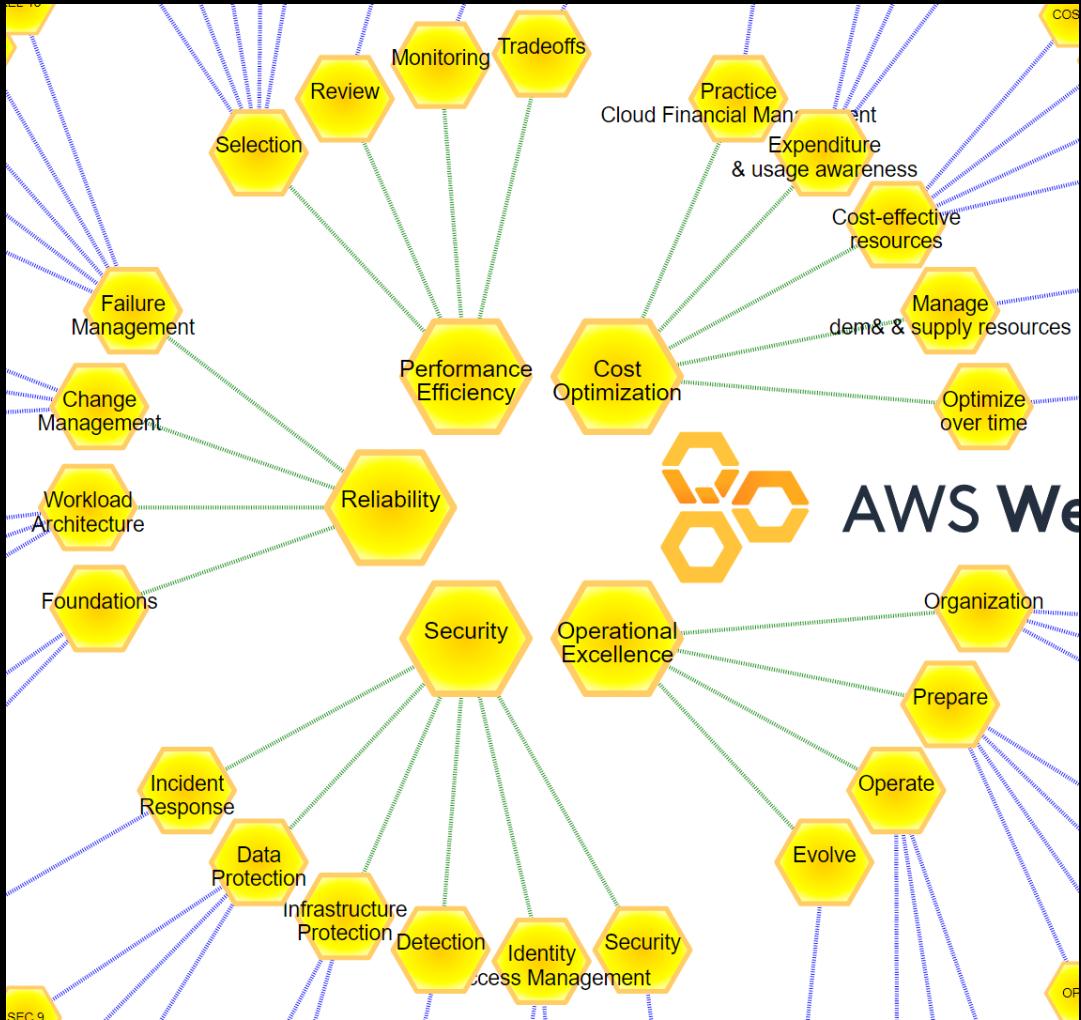
- You do NOT need to remember
 - the numbers-factors mapping
 - the cryptic taglines
 - ALL the factors
- Why is twelve factor app important?
- Explain how twelve factor app makes your code portable?
- Explain three twelve factor app principles?
- Give me an example where you couldn't follow twelve factor app principle, and why?

VIII. Concurrency

Scale out via the process model

SECTION 2 – REUSABLE PARTS OF SYSTEM DESIGN

5 Pillars of AWS Well Architected Framework (Not just for AWS)



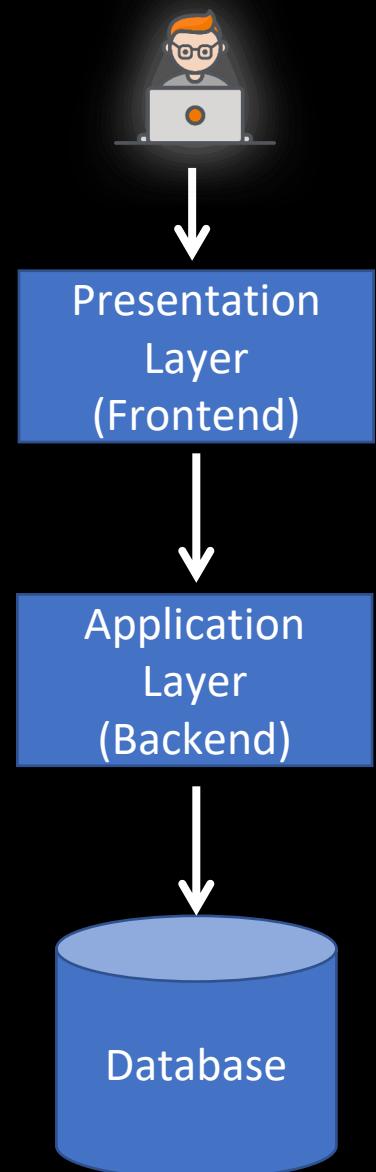
<https://wa.aws.amazon.com/map.html>

Impact on System Design

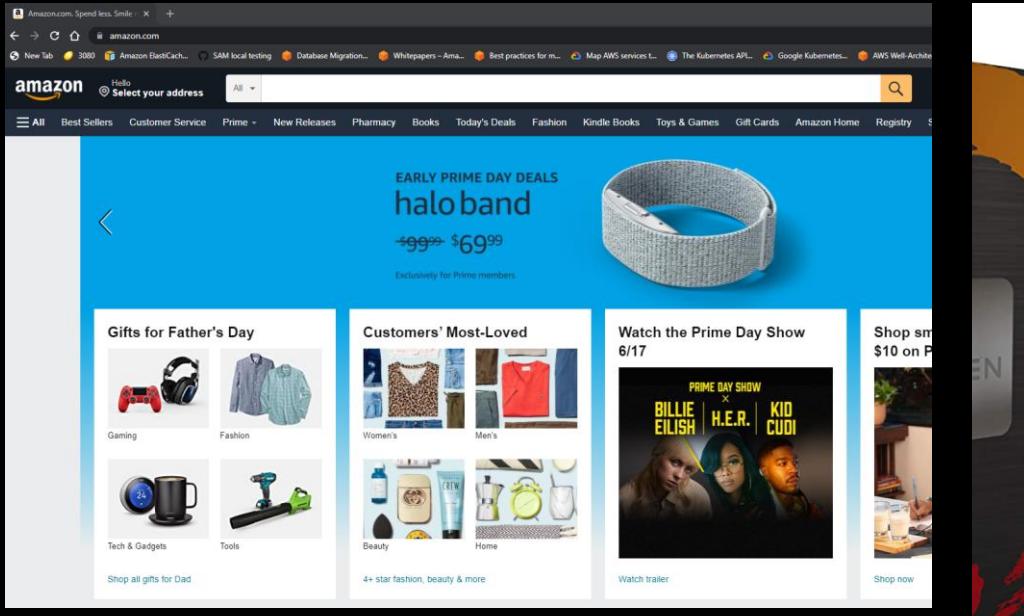
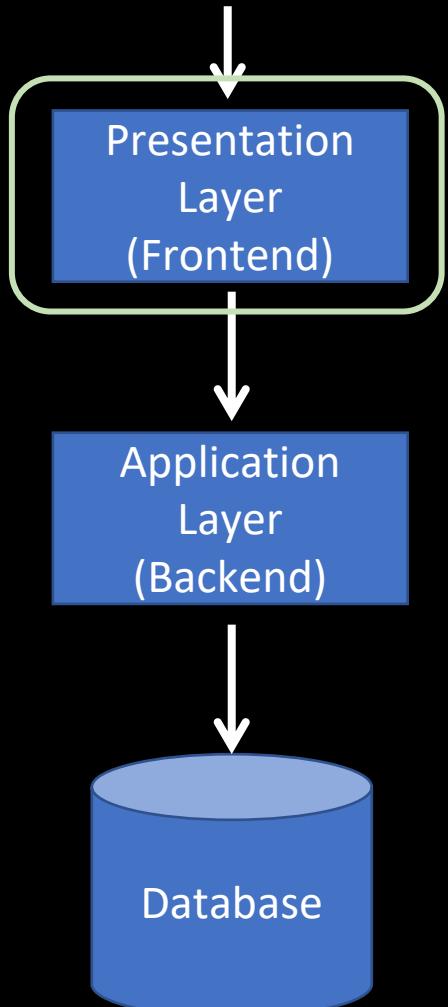
- Use this to answer the interview q – “How do you ensure your design is good?”
- Understand the priority for the application
- Well Architected Review (WAR)

Three-Tier Architecture

3 Tiers



3 Tiers



AMD Ryzen 7 5800X 8-core, 16-Thread
Unlocked Desktop Processor

Visit the AMD Store

★★★★★ 2,854 ratings | 98 answered questions
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Brand AMD

CPU AMD

Manufacturer

CPU Model AMD Ryzen 7

CPU Speed 4.7 GHz

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Buy Now

Secure transaction

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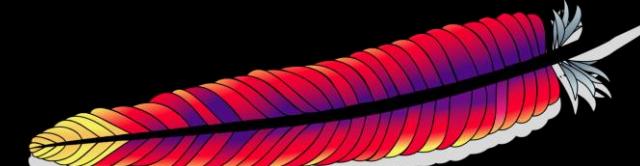
Sold by Amazon.com

Return policy: This item is
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Support: Free Amazon tech
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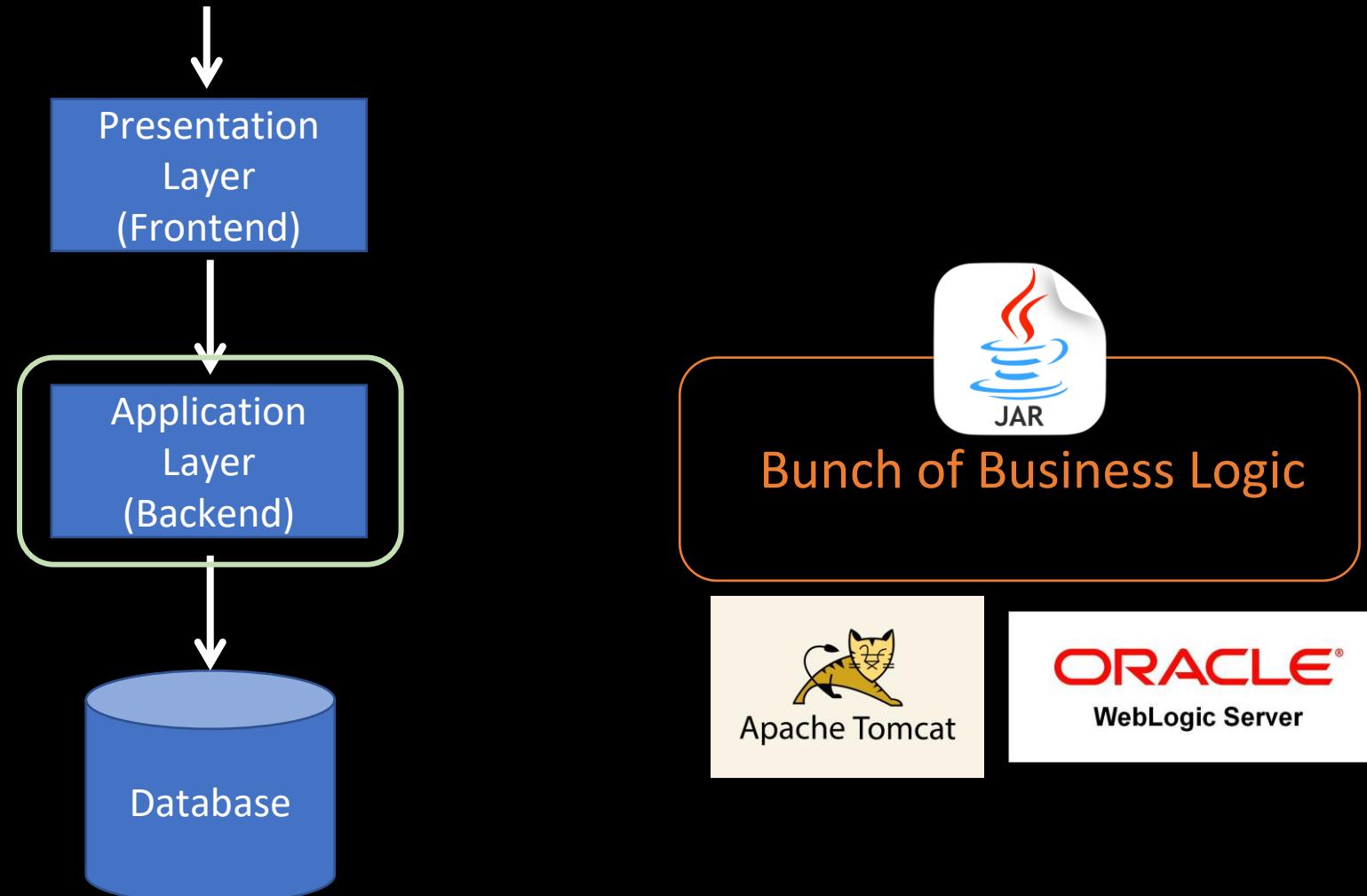


Enjoy fast, FREE delivery.

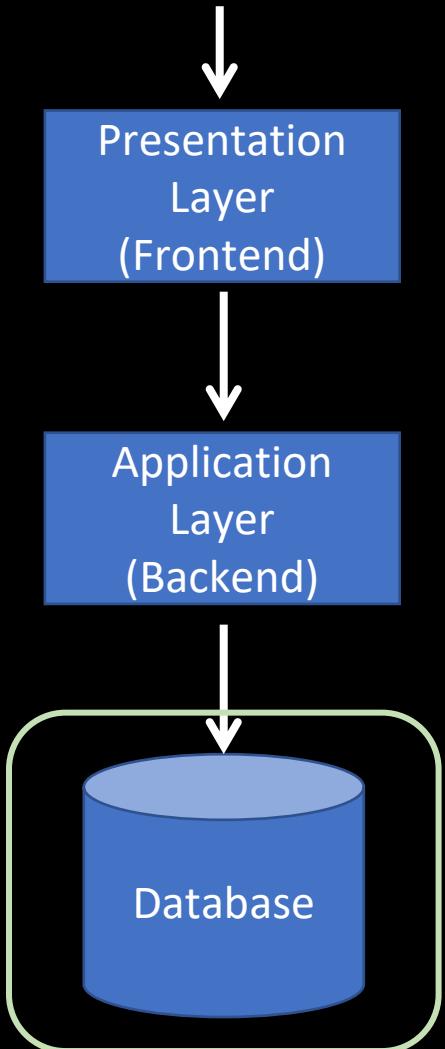


Apache Web Server

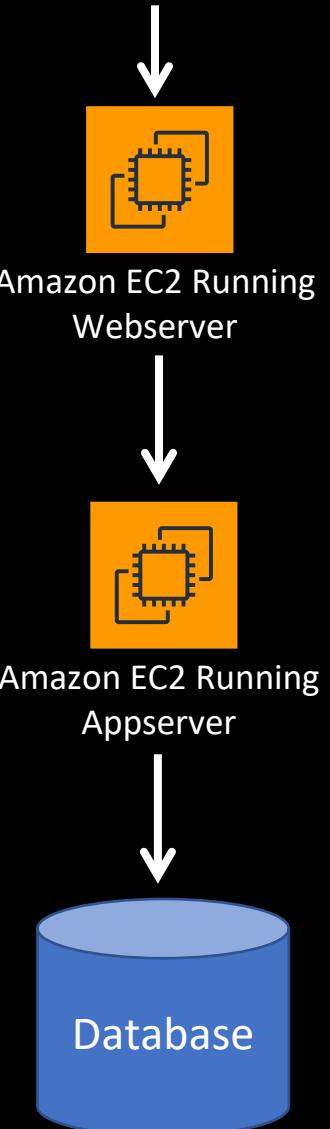
3 Tiers



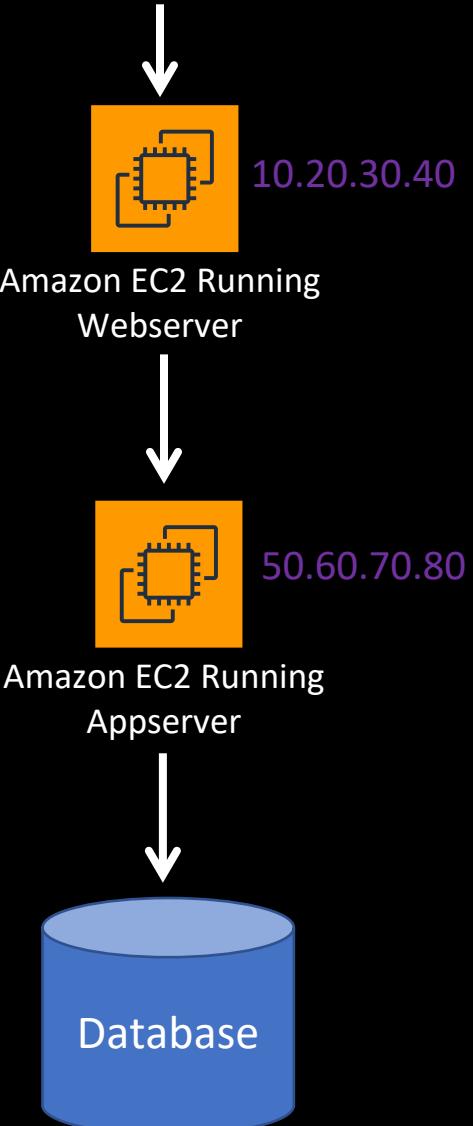
3 Tiers



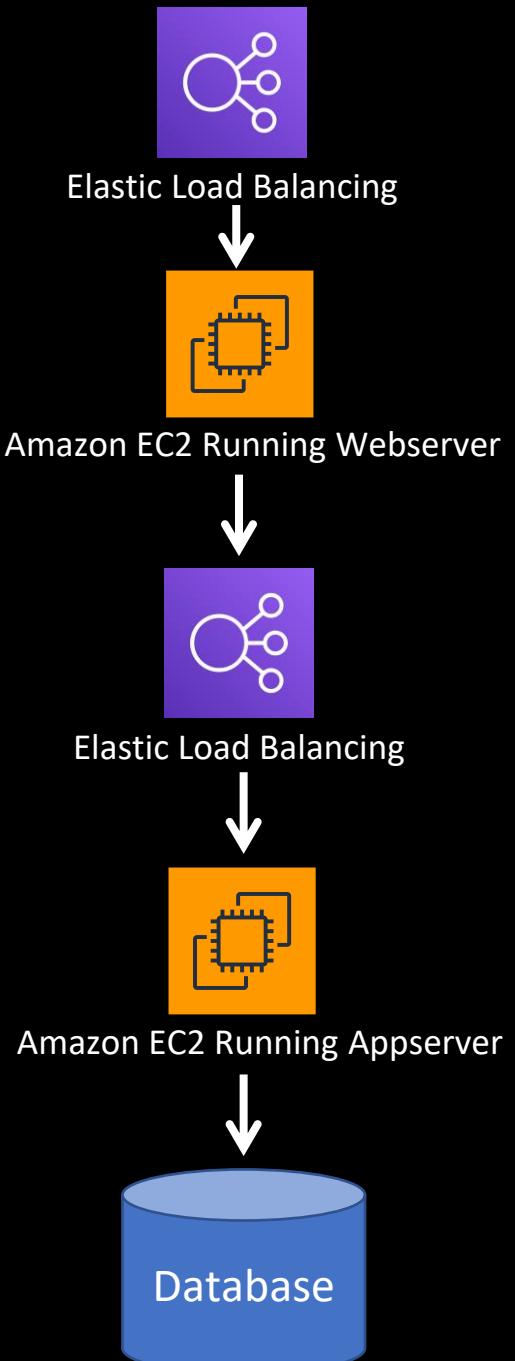
3 Tiers



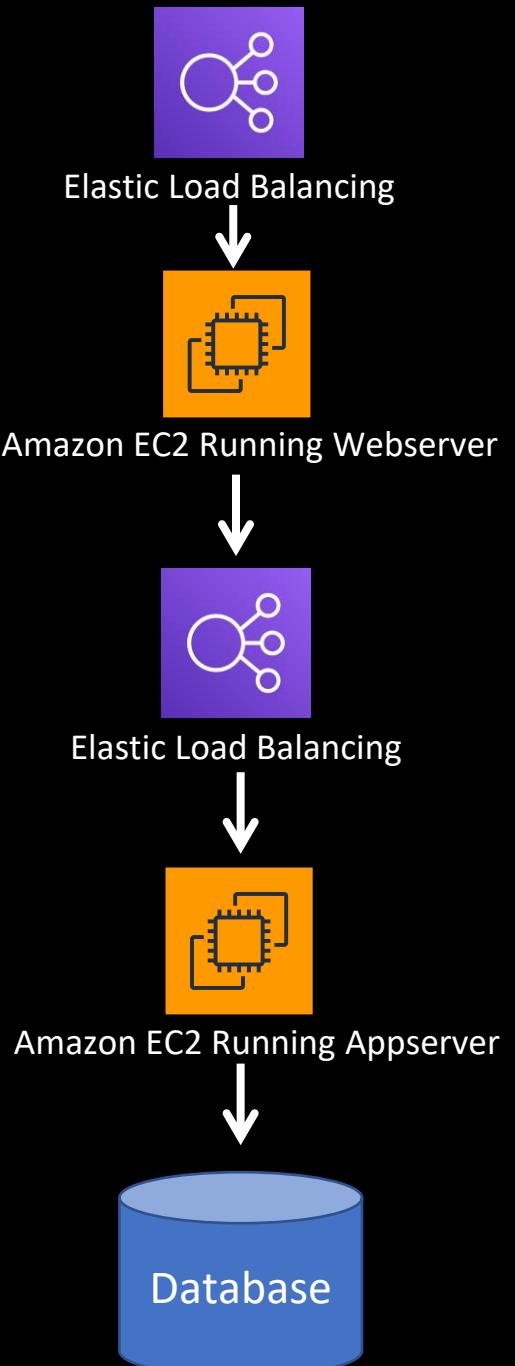
3 Tiers



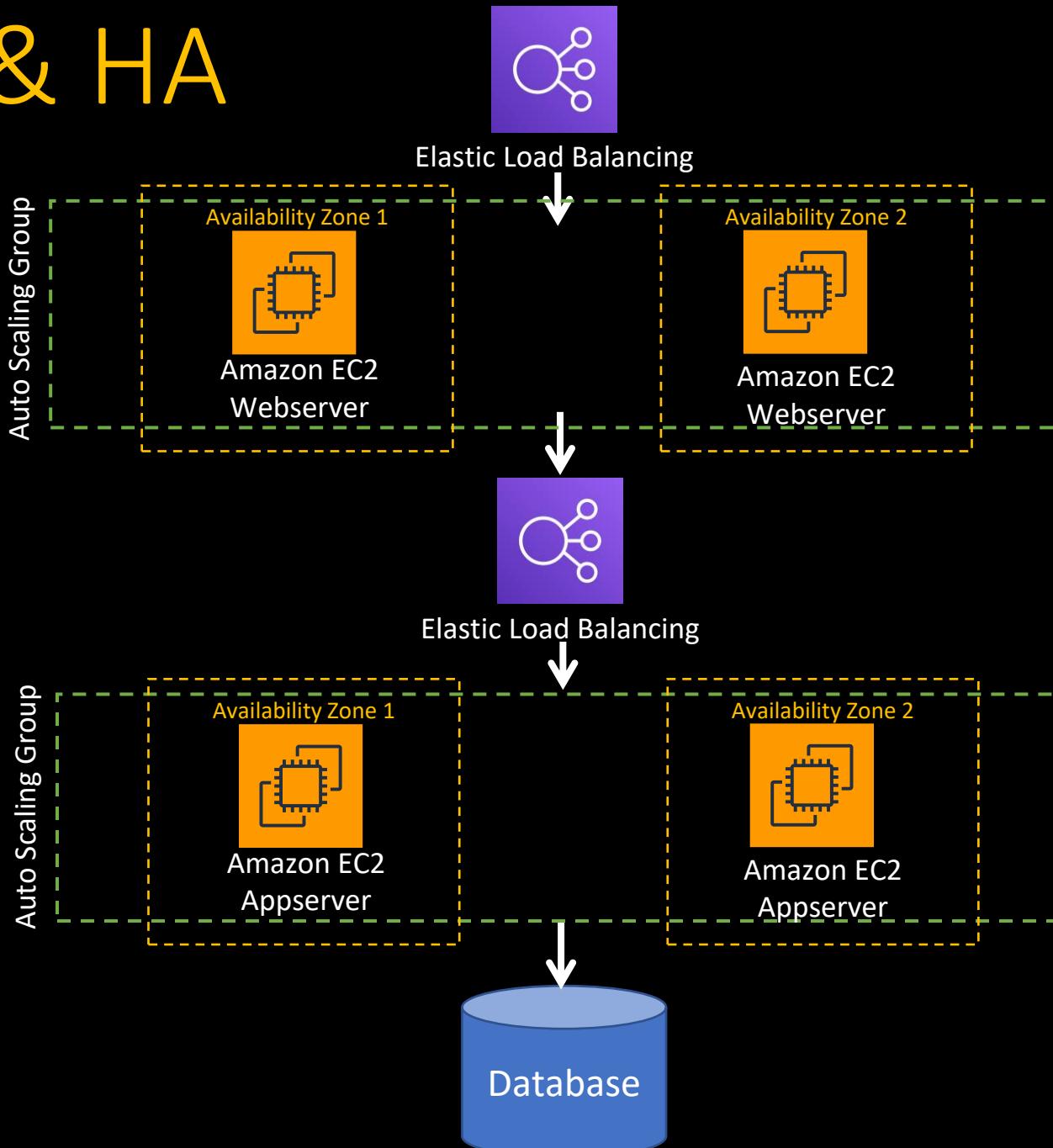
3 Tiers



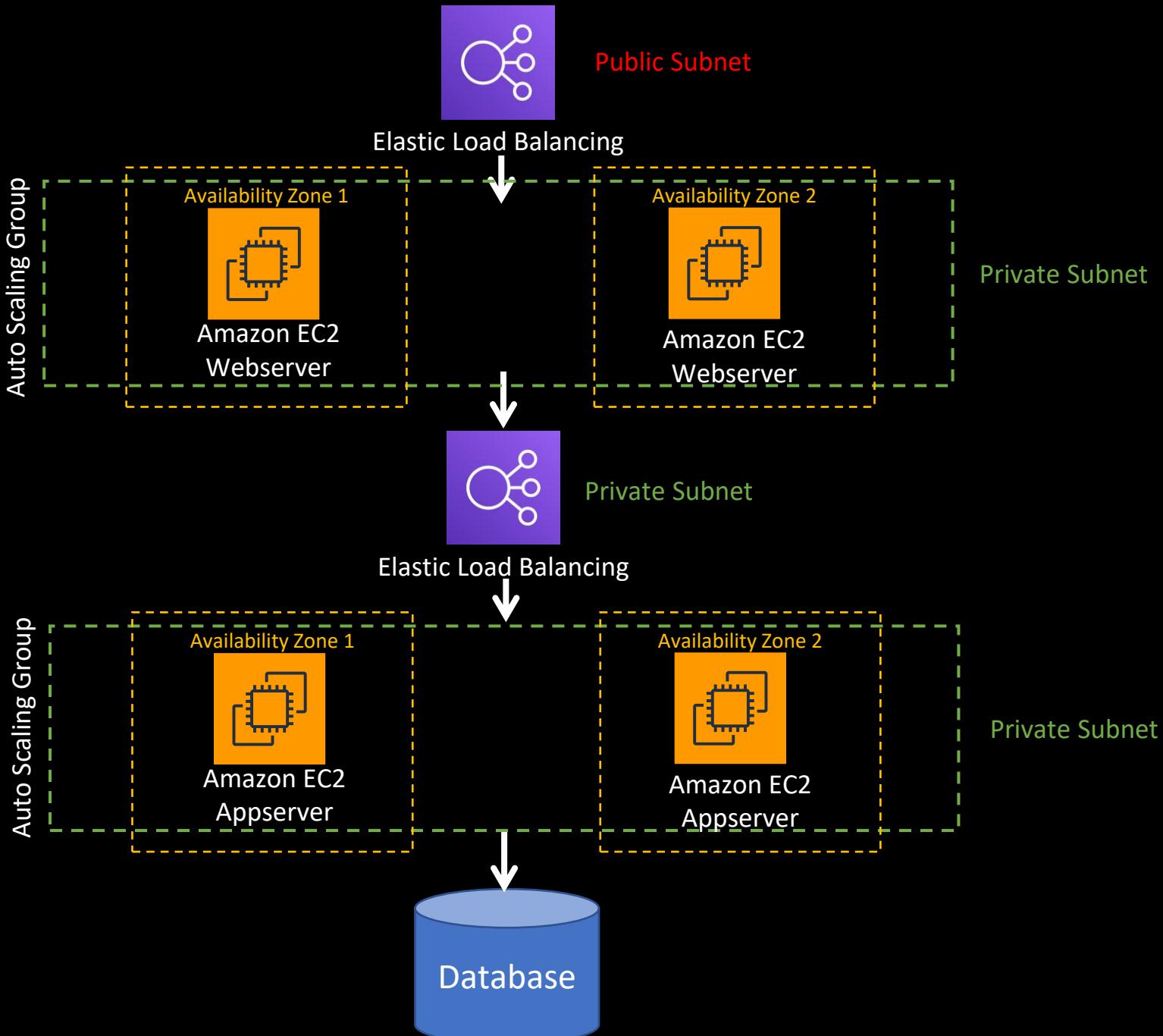
Single Points Of Failure



Scalable & HA

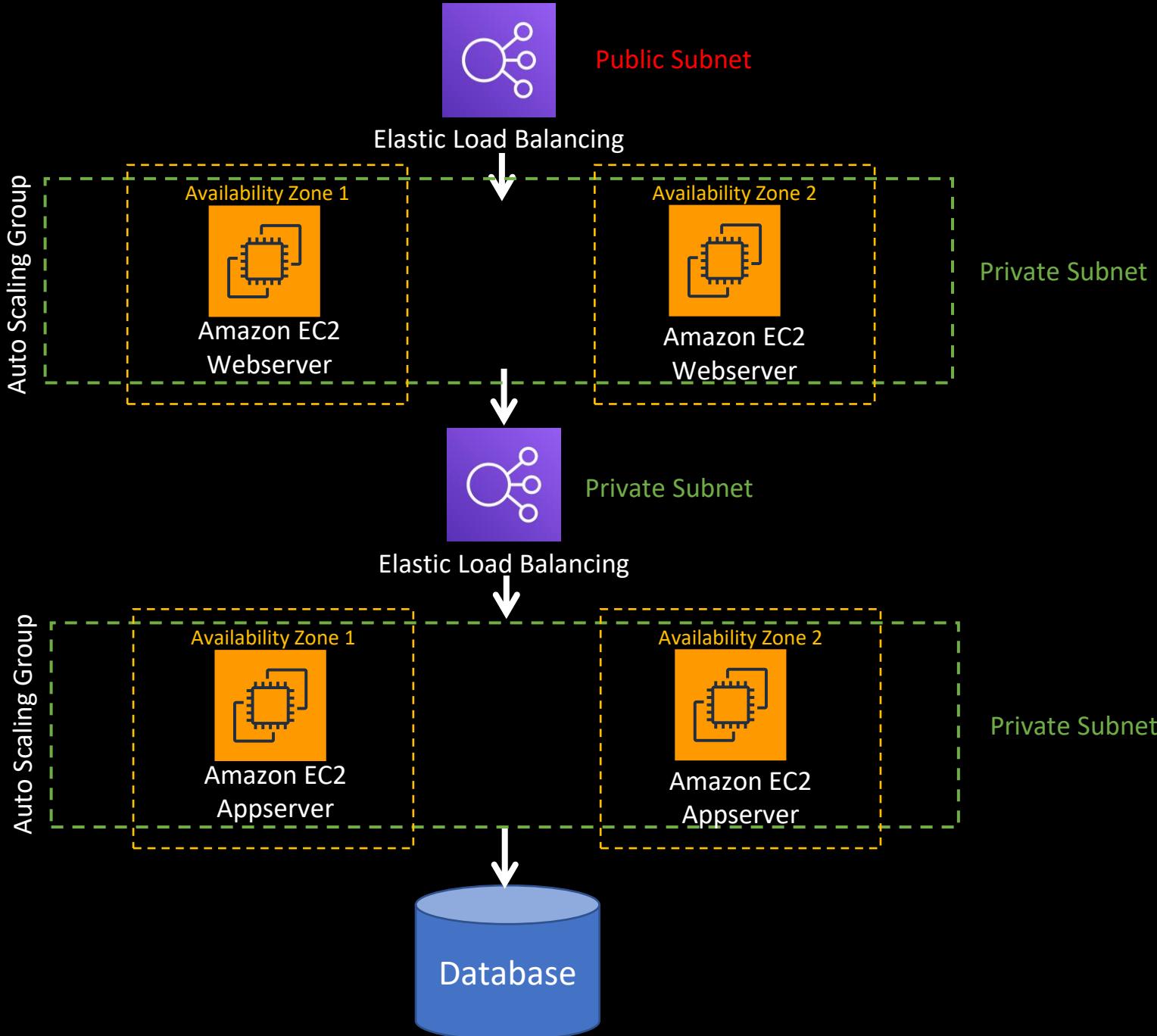


Network Security



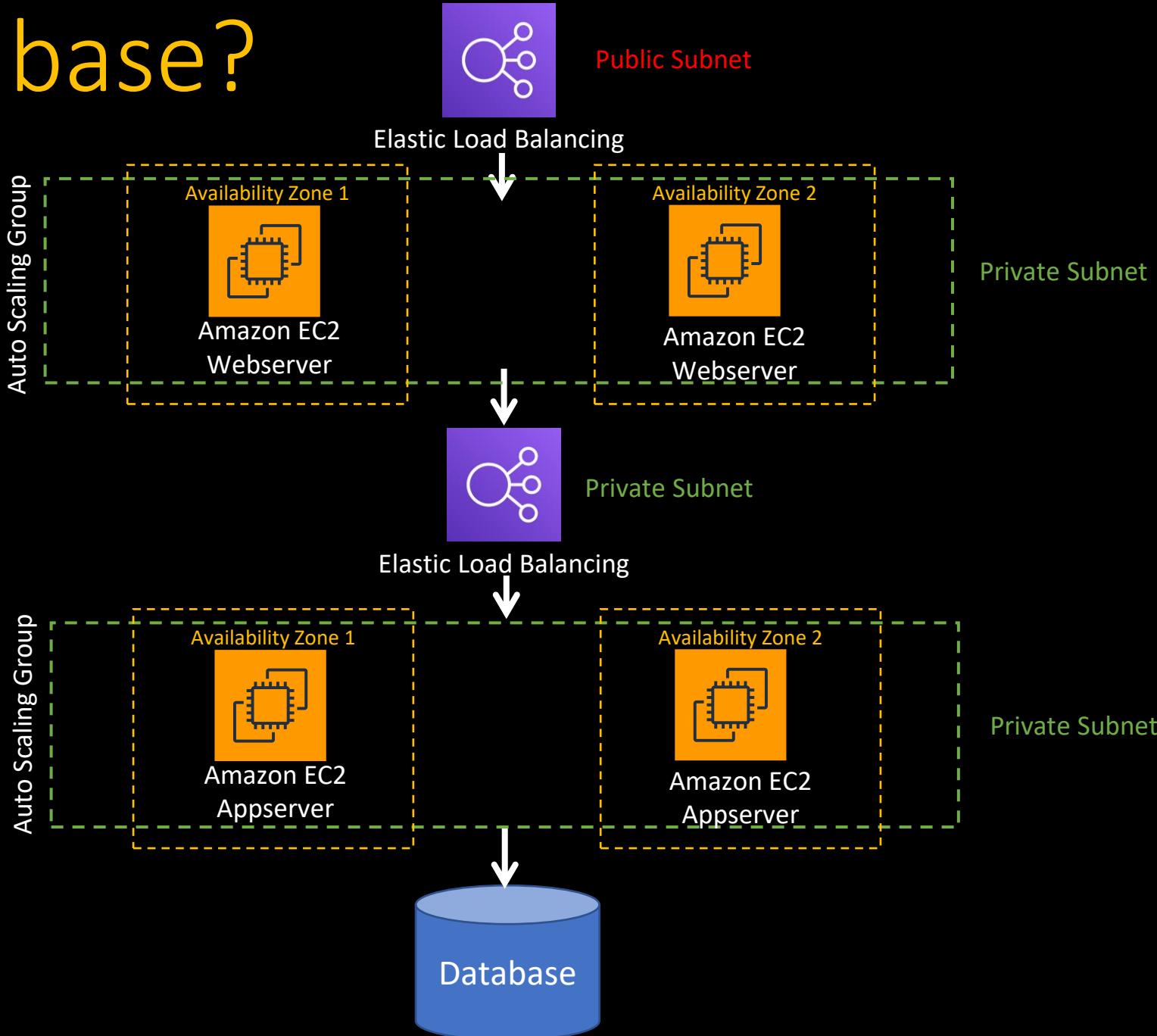
Network Security

- NACL
- Security Group
- WAF with Load Balancer



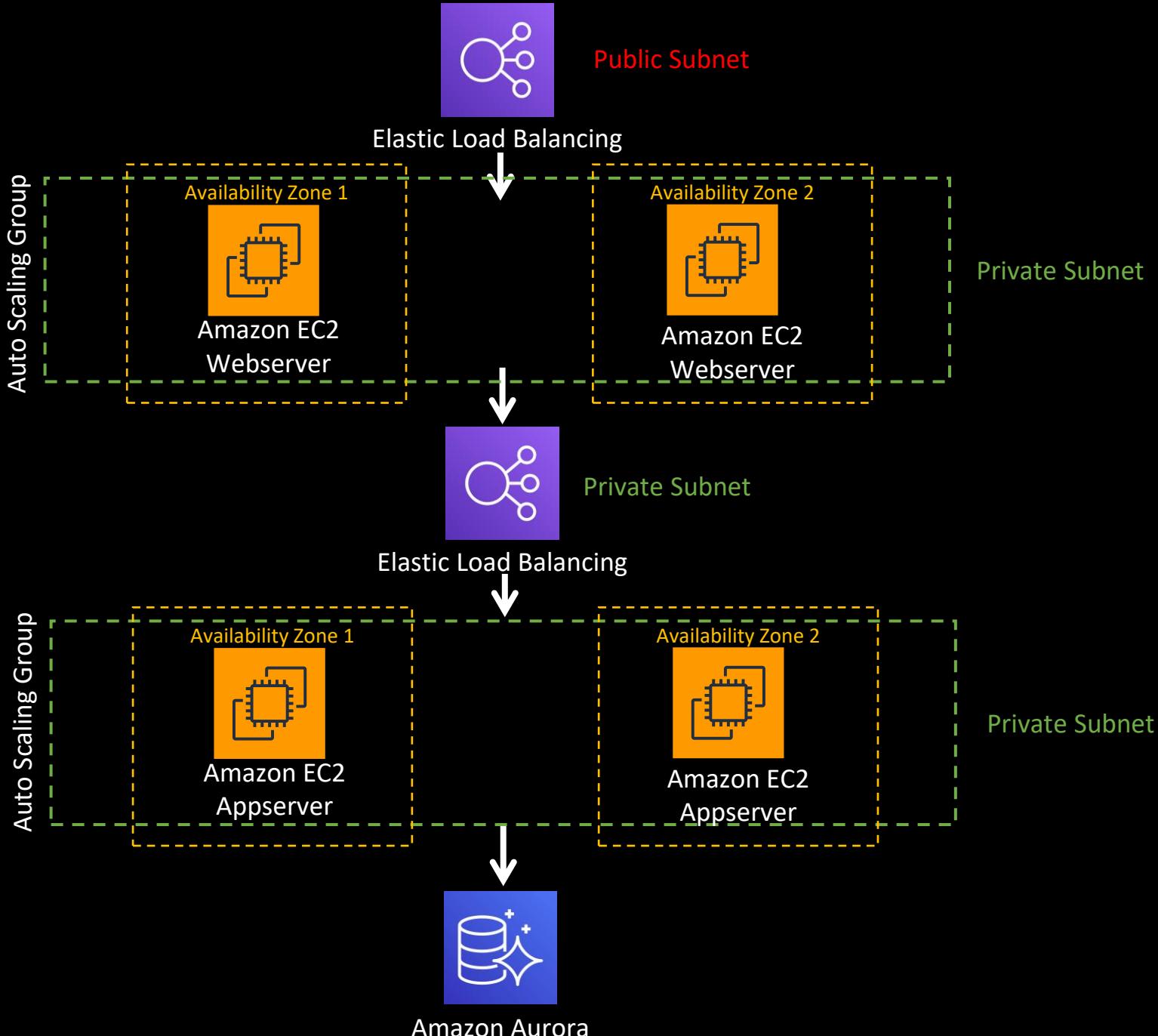
How about Database?

- SQL Vs. NoSQL
- Use AWS Native Databases



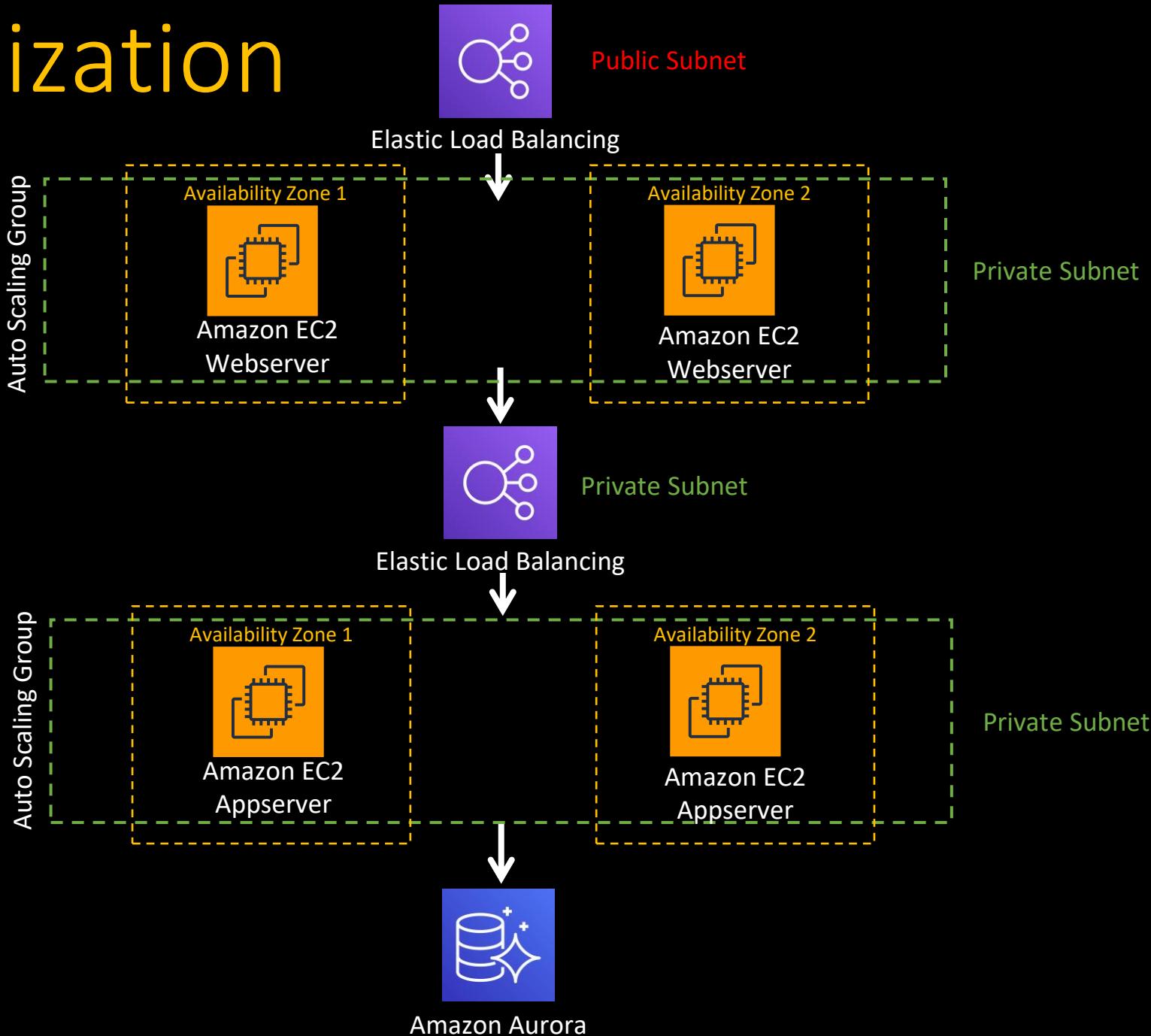
Database HA

- Multi-AZ
- Global Database (Replication)

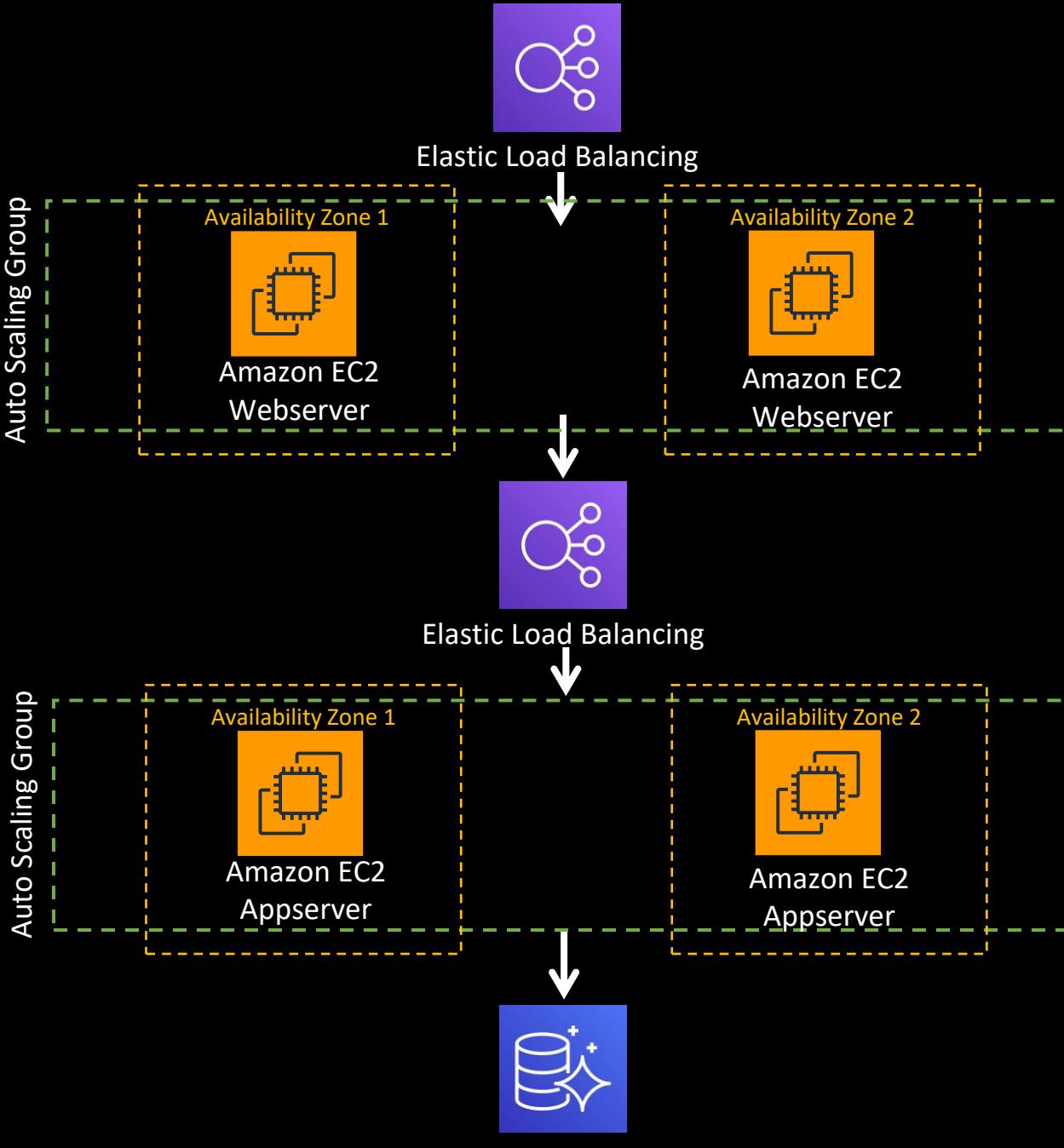


Database Optimization

- Read Replica
- Caching Layer
- Query Tuning



Presentation Layer

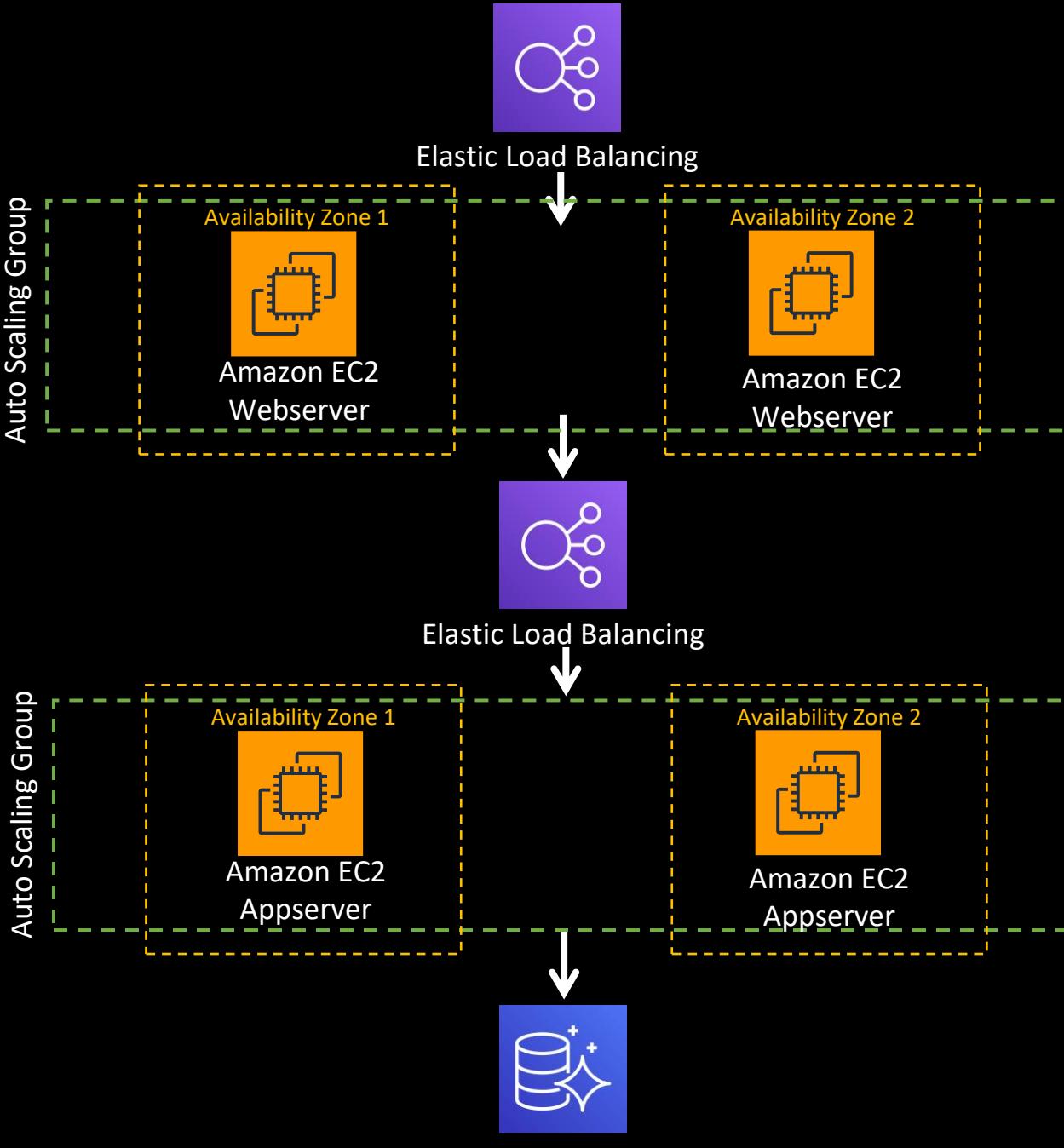


Application Layer

Database

Three-Tier Architecture with Serverless

Presentation Layer



Application Layer

Database

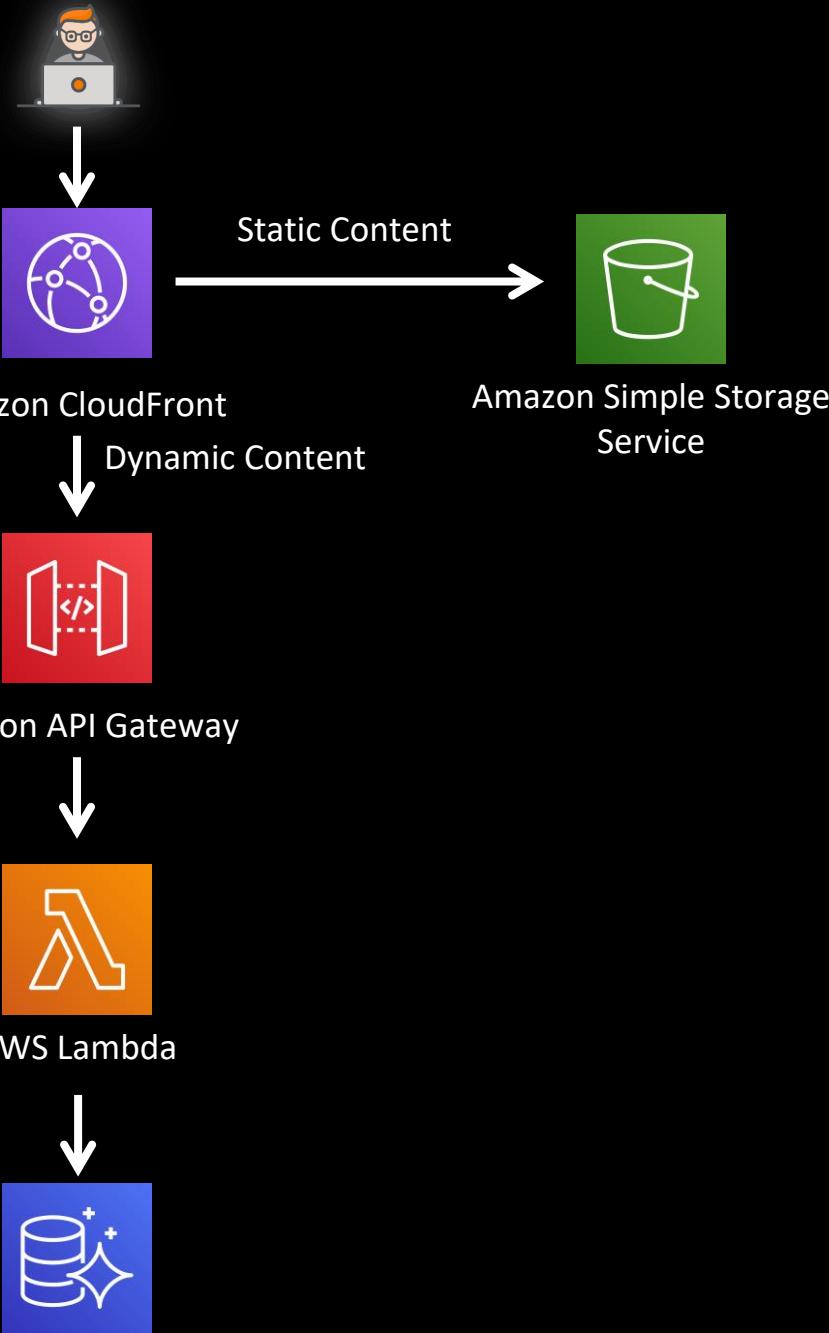
Presentation Layer

Application Layer

Database

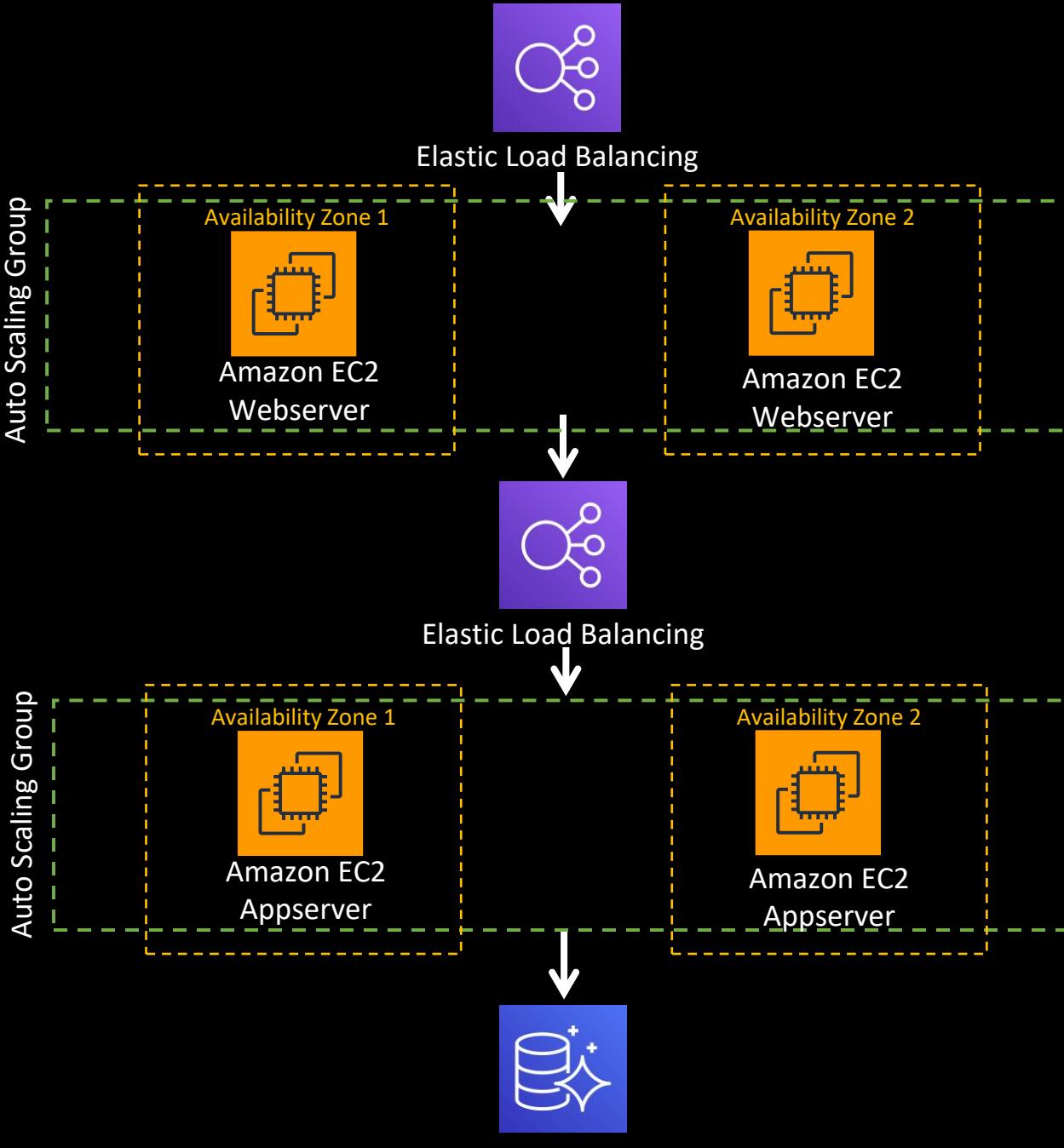
Amazon Aurora

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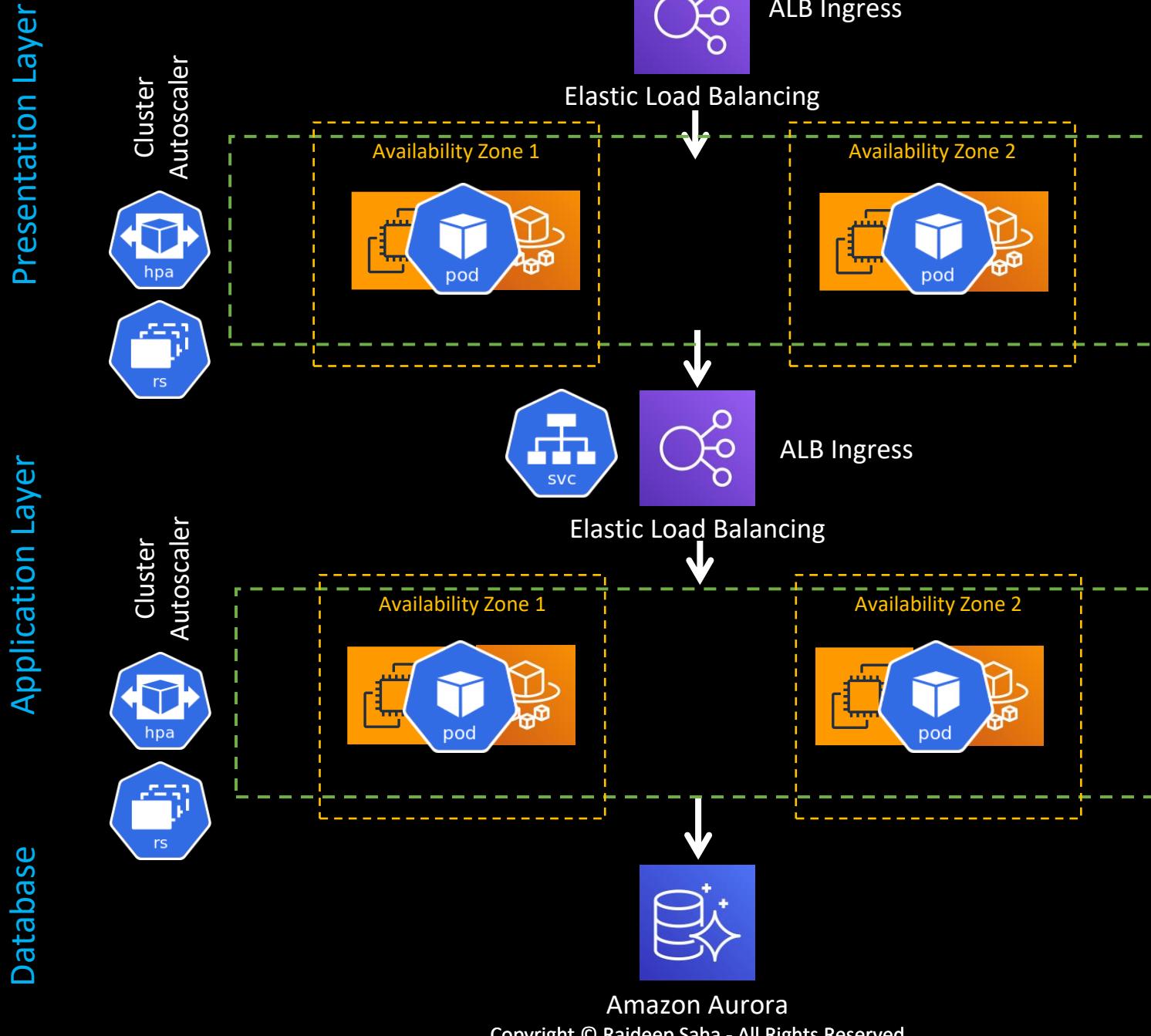
Three-Tier Architecture with Kubernetes

Presentation Layer



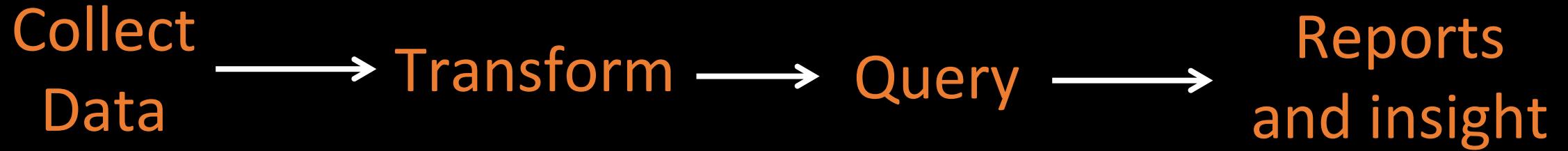
Application Layer

Database



Data Analytics System Design on AWS

Steps of Data Analytics



Steps of Data Analytics

Collect
Data



Amazon Kinesis



Amazon Managed
Streaming for Kafka

→ Transform → Query →

Reports
and insight



AWS Glue



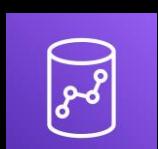
Amazon EMR



Amazon Simple Storage
Service



Amazon Athena



Amazon Redshift



Amazon Elasticsearch
Service



Amazon QuickSight



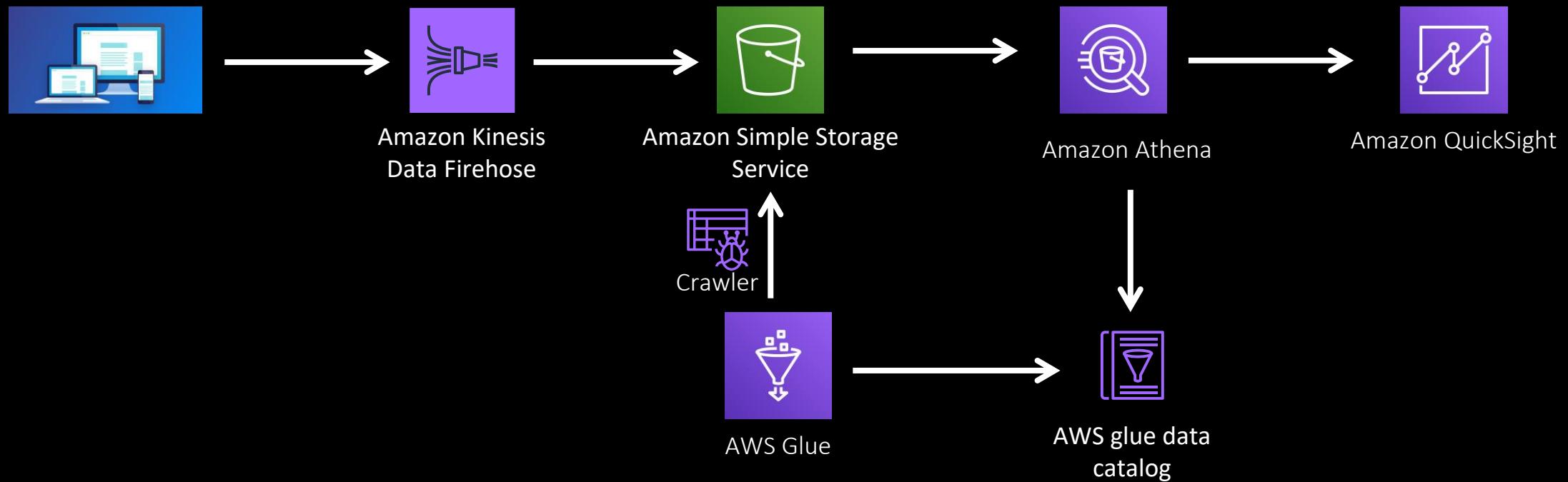
Amazon EMR



Amazon SageMaker

Sample Architecture #1

Query and report on click stream



Sample Architecture #2a

ETL and data warehouse



Sample Architecture #2b

ETL and data warehouse



Quick Detour into AWS Glue



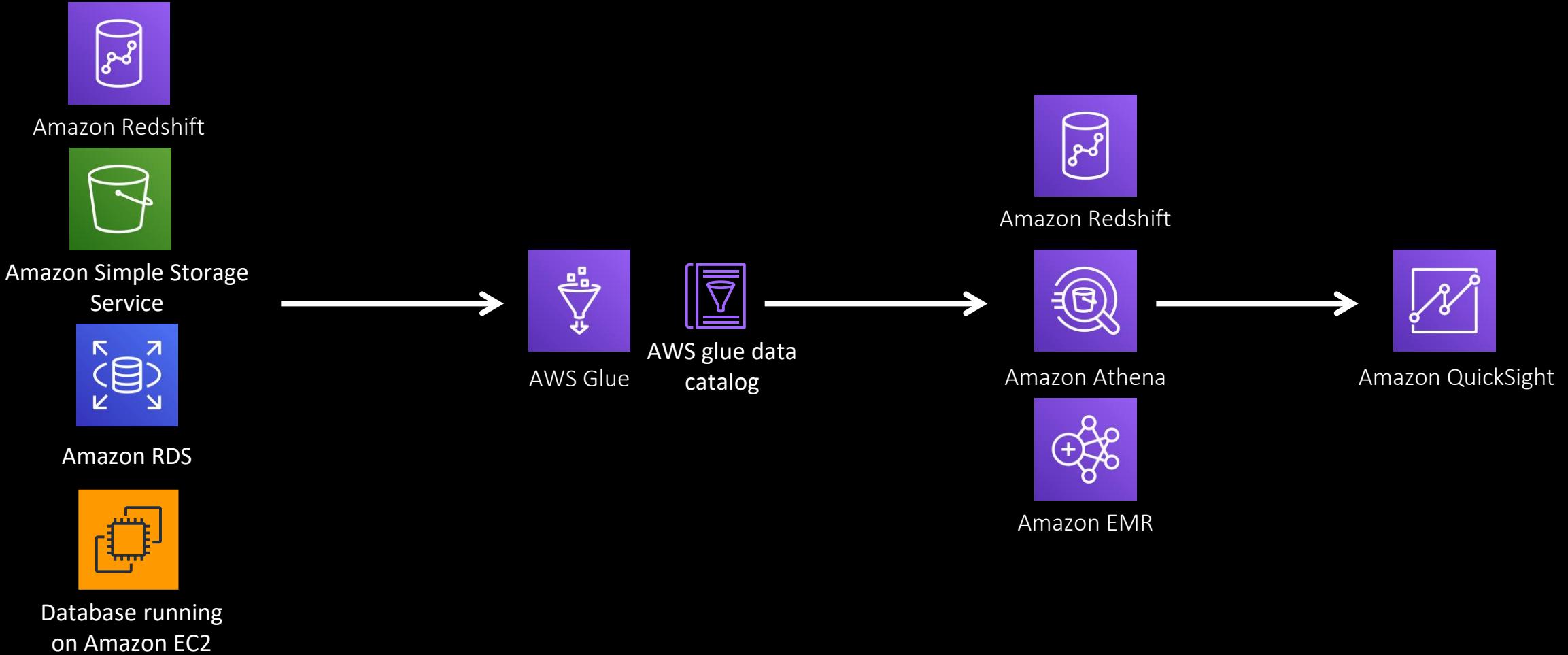
AWS Glue



- Serverless data integration tool
- Glue crawlers can run on data and create metadata
- Visually create ETL flow (Supports Python/Spark and Scala)
- Enrich, clean, and normalize data without writing code (Glue Databrew)
- Replicate data across various sources (Glue Elastic Views)

Sample Architecture #3

Unified catalog across multiple data stores



Amazon EMR

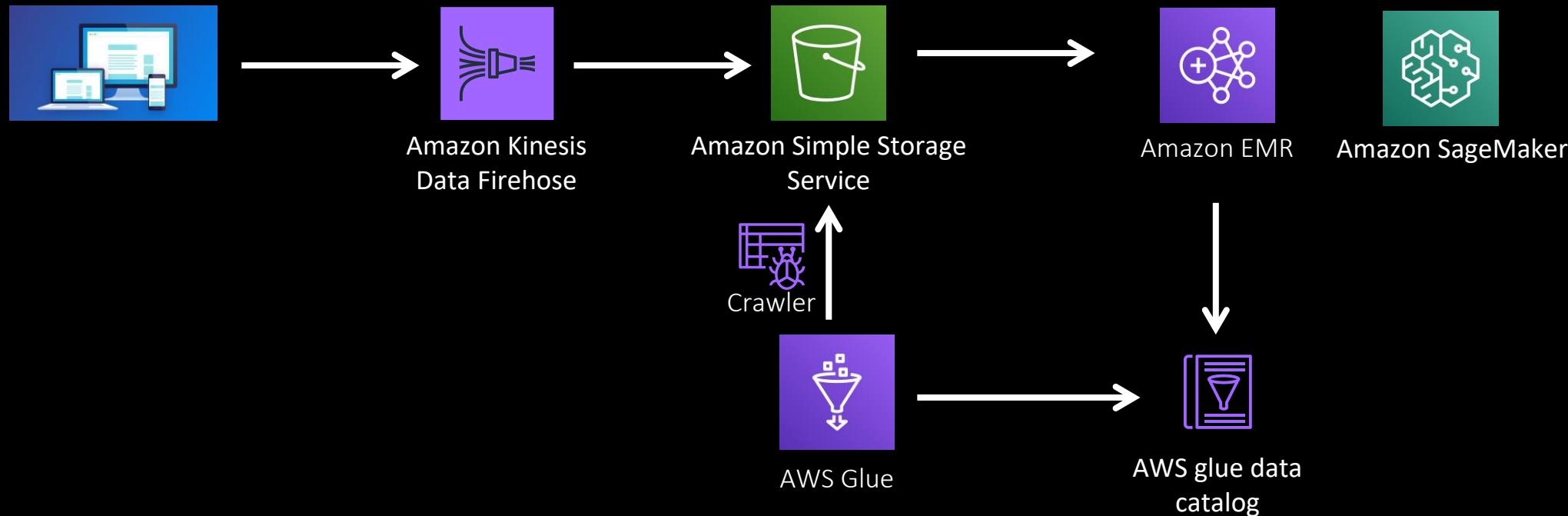


Amazon EMR

- Managed big data platform from AWS
- Runs open-source tools – Apache Spark, Apache Hive, Apache Hbase, Apache Flink, Apache Hudi, and Presto
- Run on EC2 or EKS (Elastic Kubernetes Service), or on-prem using EMR on Outposts

Sample Architecture #4

Big data analysis of click stream data

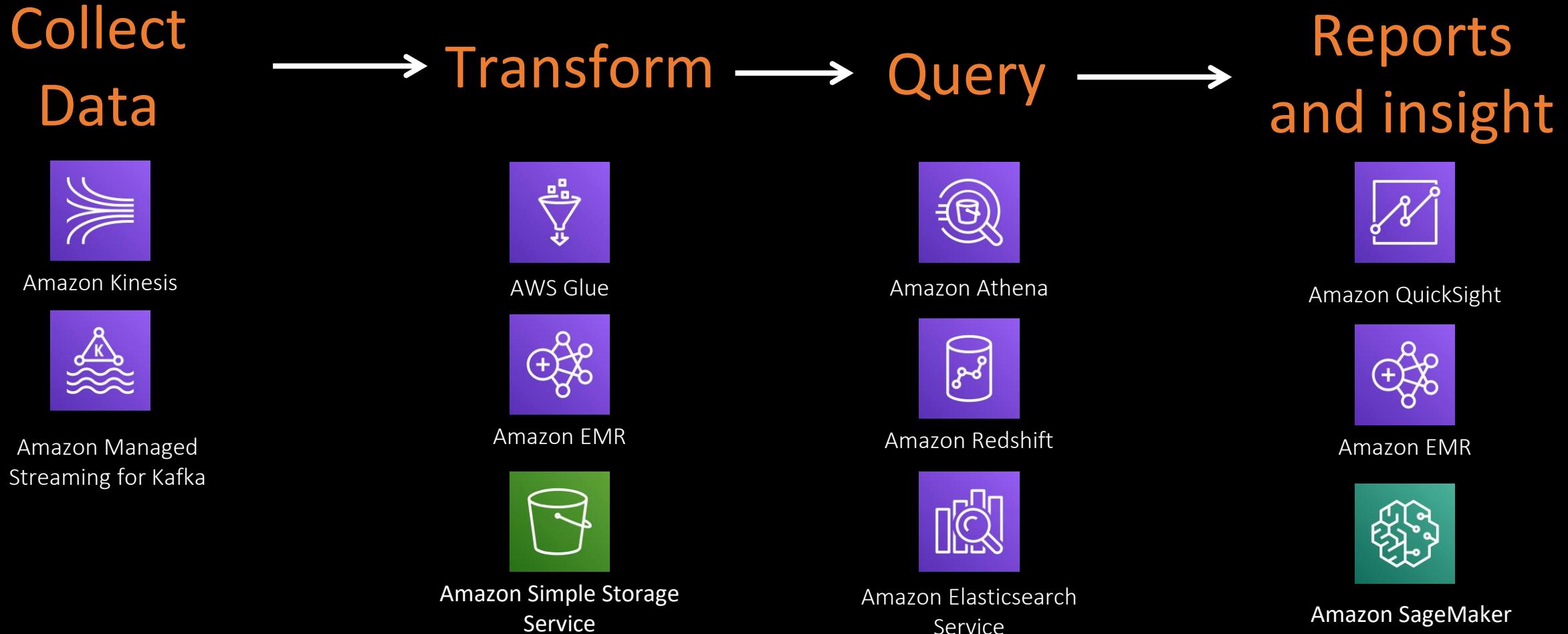


Sample Architecture #5

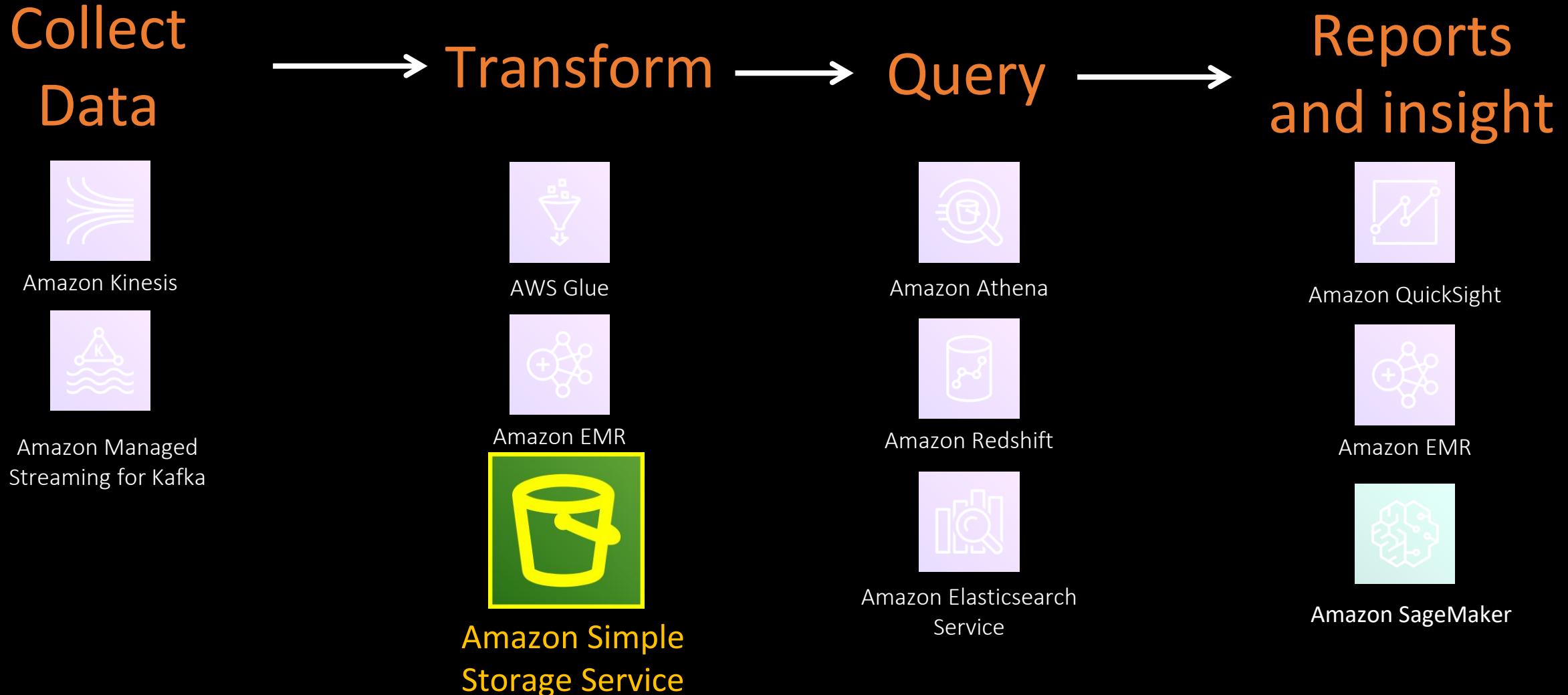
In stream querying and ETL



The Illusive Data Lake



The Illusive Data Lake



Using Well Architected for Performance/Cost Optimization (Challenge Faced Question)

Tackling Any Tuning/Troubleshooting

- Monitor
- Measure
- Remediate

Tackling Any Tuning/Troubleshooting

- Monitor
 - Logs
 - Metrics
 - Traces
- Measure
 - Define KPI
 - Send alarms
- Remediate
 - Configuration
 - Code

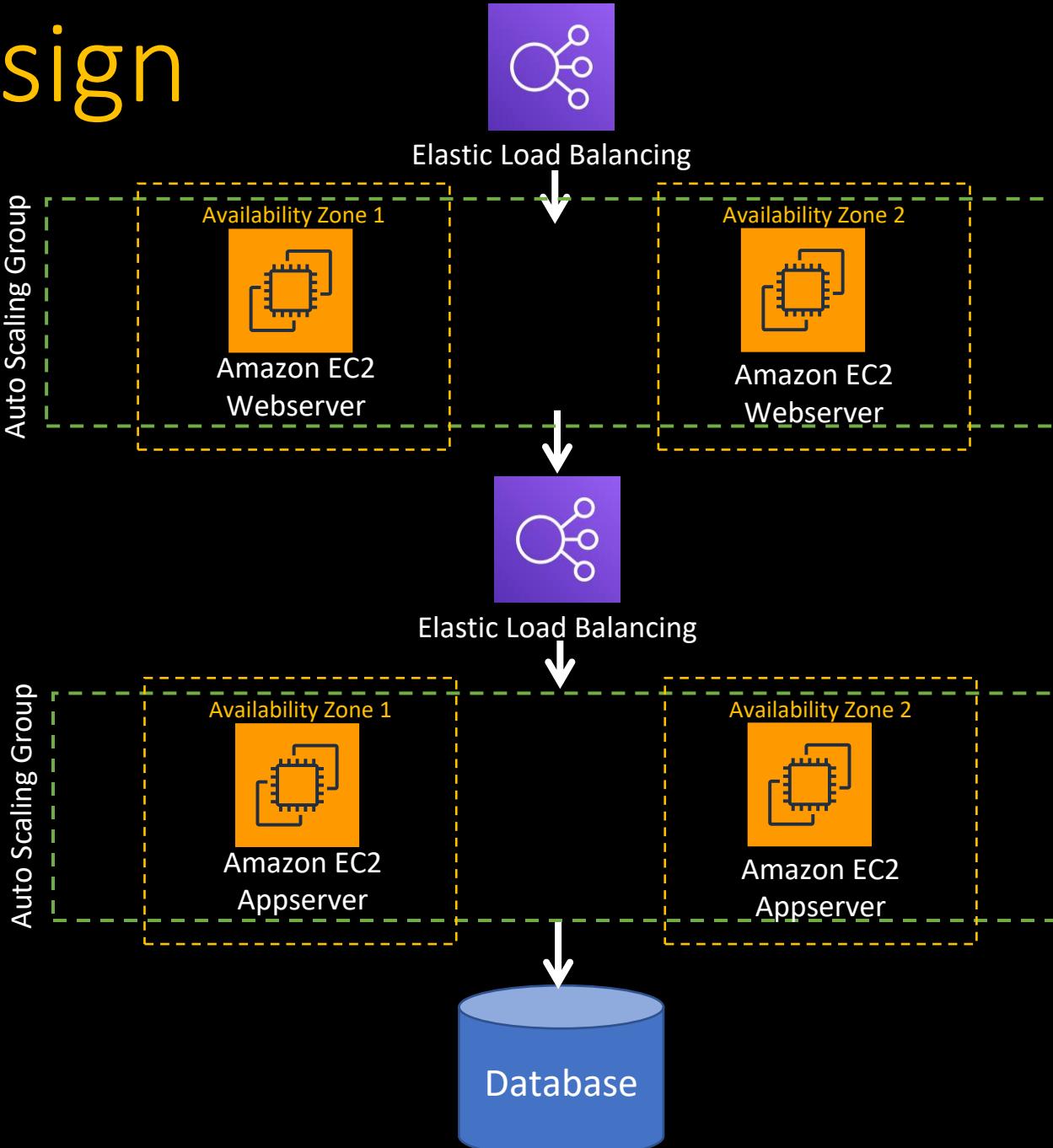
EC2 Based Application

- Monitor
 - Logs
 - Metrics – CPU/Memory Utilization on CloudWatch
 - Traces
- Measure
 - Define KPI
 - Send alarms – CloudWatch Alarm
- Remediate
 - Configuration – Used home grown algorithm/compute optimizer to optimize EC2 capacity
 - Code

Lambda Based Application

- Monitor
 - Logs
 - Metrics – Lambda is throttling (but already have high memory)
 - Traces – Enabled X-Ray trace
- Measure
 - Define KPI – found which section is taking longer
 - Send alarms
- Remediate
 - Configuration
 - Code – Moved database connection to global section

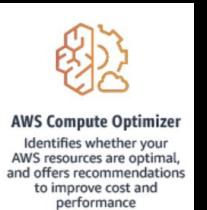
3-Tier Design



Amazon CloudWatch



AWS X-Ray



AWS Compute Optimizer
Identifies whether your AWS resources are optimal, and offers recommendations to improve cost and performance



AWS Cost Explorer



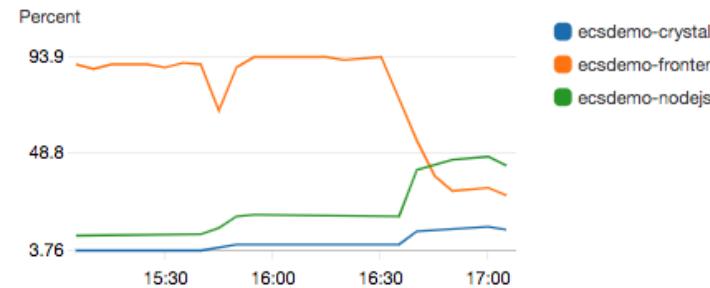
ECS Services ▾

fargate-demo-ECSClust... ▾

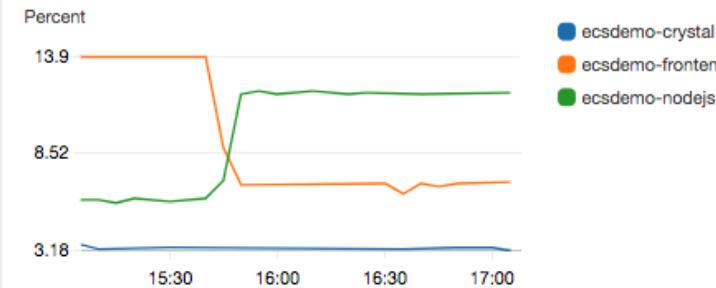
Filters: Filter services...

CloudWatch has recently announced the open preview of Container Insights to monitor your EKS and Kubernetes clusters. Please provide feedback through this link. You can also send email directly to containerinsightsfeedback@amazon.com.

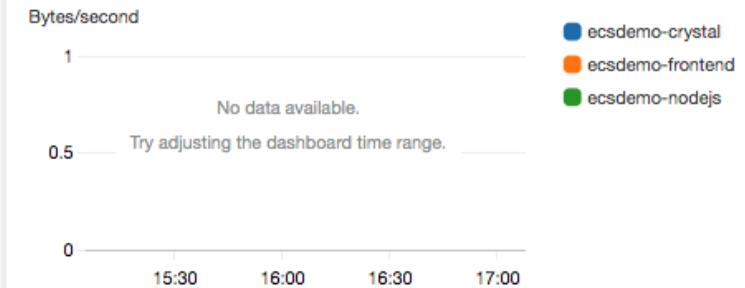
CPU Utilization



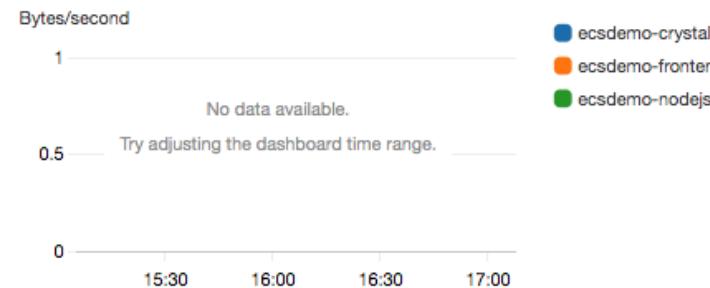
Memory Utilization



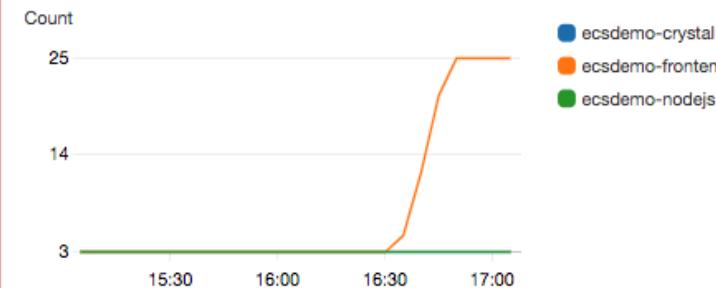
Network TX



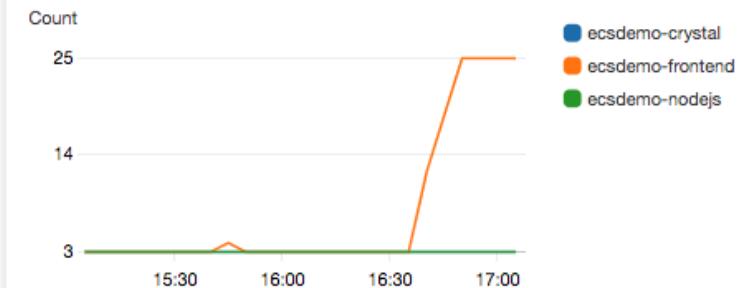
Network RX



Number of Desired Tasks



Number of Running Tasks



Number of Pending Tasks



Number of Task Sets



Number of Deployments

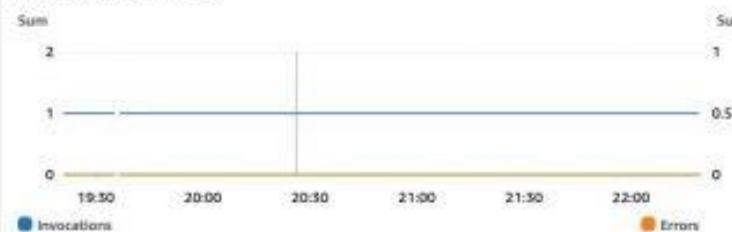


Performance monitoring

1h 3h 12h 1d 3d 1w Custom Add to dashboard

Single function ServiceTestStack-lambdaCPULambdaCPU...
 ⚠ In alarm 0 ⌚ Insufficient data 0 ✔ OK 0

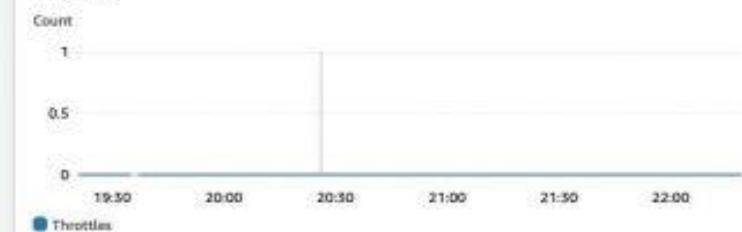
Invocations & Errors



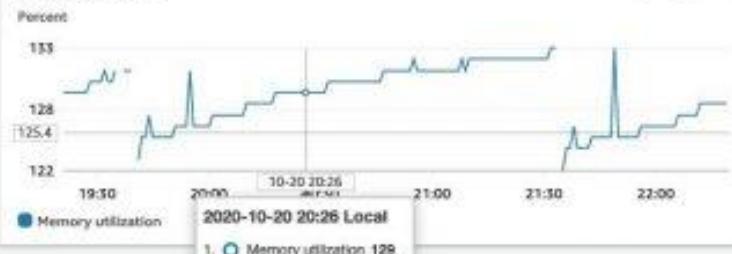
Duration



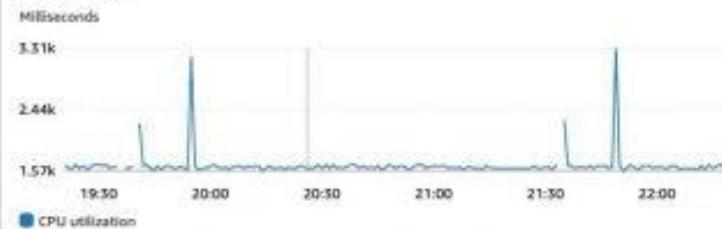
Throttles



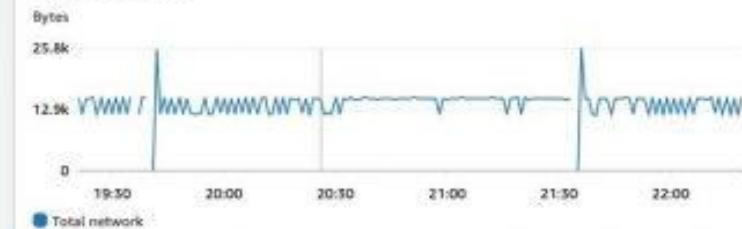
Memory Usage



CPU Usage



Network Usage

 Invocations Application logs

Most recent 1000 invocations (177)

 < 1 2 3 >

| <input type="checkbox"/> | Timestamp | Request ID | Trace | Memory % | Network IO | CPU time | Cold start |
|--------------------------|---------------------------------|-----------------------------------|--|--|------------|----------|------------|
| <input type="checkbox"/> | 2020-10-21 02:18:43 (UTC-04:00) | 6e7d206c-180c-4301-8eff-ad9262... | View <input type="button" value=""/> | <div style="width: 128%; height: 10px; background-color: #0070C0;"></div> 128% | 11 kB | 1600ms | - |
| <input type="checkbox"/> | 2020-10-21 02:17:43 (UTC-04:00) | 75652a4f-4a26-4703-a7db-de362... | View <input type="button" value=""/> | <div style="width: 128%; height: 10px; background-color: #0070C0;"></div> 128% | 14 kB | 1650ms | - |
| <input type="checkbox"/> | 2020-10-21 02:16:43 (UTC-04:00) | 21e0c8a7-cb97-47b1-88ae-31ef0... | View <input type="button" value=""/> | <div style="width: 128%; height: 10px; background-color: #0070C0;"></div> 128% | 11 kB | 1640ms | - |
| <input type="checkbox"/> | 2020-10-21 02:15:43 (UTC-04:00) | 24a1fcf1-0812-459d-a3c7-91d59... | View <input type="button" value=""/> | <div style="width: 128%; height: 10px; background-color: #0070C0;"></div> 128% | 14 kB | 1600ms | - |
| <input type="checkbox"/> | 2020-10-21 02:14:43 (UTC-04:00) | 04d56aa2-4a64-4309-88f0-50603... | View <input type="button" value=""/> | <div style="width: 128%; height: 10px; background-color: #0070C0;"></div> 128% | 11 kB | 1650ms | - |



Clients





AWS X-Ray

Getting Started

Service map

Traces

Enter Service Name, Annotation, Trace ID or click the Help icon for additional details



Traces > 1-58214aaa-26811b4a16897a938c977b5e

Timeline

Raw

| Name | Res. | Duration | Status | 0.0ms | 100ms | 200ms | 300ms | 400ms | 500ms | 600ms | 700ms | 800ms | 900ms | 1.0s | 1.1s | 1.2s |
|------|------|----------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|
|------|------|----------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|

▼ myfront-dev.us-west-2.elasticbeanstalk.com

| | | | | | | | | | | | | | | | | | |
|--|-----|---------|---|-----|-----------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|-------------|-------------|-------------|
| myfront-dev.us-west-2.elasticbeanstalk.com | 200 | 1.2 sec | ✓ | [] | 0 - 100ms | 100 - 200ms | 200 - 300ms | 300 - 400ms | 400 - 500ms | 500 - 600ms | 600 - 700ms | 700 - 800ms | 800 - 900ms | 900 - 1.0s | 1.0s - 1.1s | 1.1s - 1.2s | 1.2s - 1.2s |
| myapi-dev.us-west-2.elasticbeanstalk.com | 200 | 1.1 sec | ✓ | [] | 0 - 100ms | 100 - 200ms | 200 - 300ms | 300 - 400ms | 400 - 500ms | 500 - 600ms | 600 - 700ms | 700 - 800ms | 800 - 900ms | 900 - 1.0s | 1.0s - 1.1s | 1.1s - 1.2s | 1.2s - 1.2s |

▼ myapi-dev.us-west-2.elasticbeanstalk.com

| | | | | | | | | | | | | | | | | | |
|--|-----|---------|---|-----|-----------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|-------------|-------------|-------------|
| myapi-dev.us-west-2.elasticbeanstalk.com | 200 | 1.1 sec | ✓ | [] | 0 - 100ms | 100 - 200ms | 200 - 300ms | 300 - 400ms | 400 - 500ms | 500 - 600ms | 600 - 700ms | 700 - 800ms | 800 - 900ms | 900 - 1.0s | 1.0s - 1.1s | 1.1s - 1.2s | 1.2s - 1.2s |
| DynamoDB | 200 | 208 ms | ✓ | [] | 0 - 100ms | 100 - 200ms | 200 - 300ms | 300 - 400ms | 400 - 500ms | 500 - 600ms | 600 - 700ms | 700 - 800ms | 800 - 900ms | 900 - 1.0s | 1.0s - 1.1s | 1.1s - 1.2s | 1.2s - 1.2s |
| catalog.myapi.us-west-2.elasticbeanstalk.com | 200 | 842 ms | ✓ | [] | 0 - 100ms | 100 - 200ms | 200 - 300ms | 300 - 400ms | 400 - 500ms | 500 - 600ms | 600 - 700ms | 700 - 800ms | 800 - 900ms | 900 - 1.0s | 1.0s - 1.1s | 1.1s - 1.2s | 1.2s - 1.2s |

▼ catalog.myapi.us-west-2.elasticbeanstalk.com

| | | | | | | | | | | | | | | | | | |
|--|-----|--------|-----|--|-----------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|-------------|-------------|-------------|
| catalog.myapi.us-west-2.elasticbeanstalk.com | 200 | 842 ms | ✓ | [] | 0 - 100ms | 100 - 200ms | 200 - 300ms | 300 - 400ms | 400 - 500ms | 500 - 600ms | 600 - 700ms | 700 - 800ms | 800 - 900ms | 900 - 1.0s | 1.0s - 1.1s | 1.1s - 1.2s | 1.2s - 1.2s |
| Auth | - | 297 ms | ✓ | [] | 0 - 100ms | 100 - 200ms | 200 - 300ms | 300 - 400ms | 400 - 500ms | 500 - 600ms | 600 - 700ms | 700 - 800ms | 800 - 900ms | 900 - 1.0s | 1.0s - 1.1s | 1.1s - 1.2s | 1.2s - 1.2s |
| Cache | - | 281 ms | ✓ | [] | 0 - 100ms | 100 - 200ms | 200 - 300ms | 300 - 400ms | 400 - 500ms | 500 - 600ms | 600 - 700ms | 700 - 800ms | 800 - 900ms | 900 - 1.0s | 1.0s - 1.1s | 1.1s - 1.2s | 1.2s - 1.2s |
| DynamoDB | 200 | 251 ms | [] | Remote fault caused by Aws::DynamoDB::Errors::ProvisionedThroughputExceededException | 0 - 100ms | 100 - 200ms | 200 - 300ms | 300 - 400ms | 400 - 500ms | 500 - 600ms | 600 - 700ms | 700 - 800ms | 800 - 900ms | 900 - 1.0s | 1.0s - 1.1s | 1.1s - 1.2s | 1.2s - 1.2s |
| Fetch Products | - | 461 ms | [] | The level of configured provisioned throughput for the table was exceeded. Consider increasing your provisioning level with the UpdateTable API. (Click for details) | 0 - 100ms | 100 - 200ms | 200 - 300ms | 300 - 400ms | 400 - 500ms | 500 - 600ms | 600 - 700ms | 700 - 800ms | 800 - 900ms | 900 - 1.0s | 1.0s - 1.1s | 1.1s - 1.2s | 1.2s - 1.2s |
| Fetch Ret - 0 | - | 194 ms | [] | | 0 - 100ms | 100 - 200ms | 200 - 300ms | 300 - 400ms | 400 - 500ms | 500 - 600ms | 600 - 700ms | 700 - 800ms | 800 - 900ms | 900 - 1.0s | 1.0s - 1.1s | 1.1s - 1.2s | 1.2s - 1.2s |
| DynamoDB | 400 | 194 ms | ! | [] | 0 - 100ms | 100 - 200ms | 200 - 300ms | 300 - 400ms | 400 - 500ms | 500 - 600ms | 600 - 700ms | 700 - 800ms | 800 - 900ms | 900 - 1.0s | 1.0s - 1.1s | 1.1s - 1.2s | 1.2s - 1.2s |
| Fetch Ret - 1 | - | 233 ms | ✓ | [] | 0 - 100ms | 100 - 200ms | 200 - 300ms | 300 - 400ms | 400 - 500ms | 500 - 600ms | 600 - 700ms | 700 - 800ms | 800 - 900ms | 900 - 1.0s | 1.0s - 1.1s | 1.1s - 1.2s | 1.2s - 1.2s |
| DynamoDB | 200 | 233 ms | ✓ | [] | 0 - 100ms | 100 - 200ms | 200 - 300ms | 300 - 400ms | 400 - 500ms | 500 - 600ms | 600 - 700ms | 700 - 800ms | 800 - 900ms | 900 - 1.0s | 1.0s - 1.1s | 1.1s - 1.2s | 1.2s - 1.2s |

Remote fault caused by Aws::DynamoDB::Errors::ProvisionedThroughputExceededException

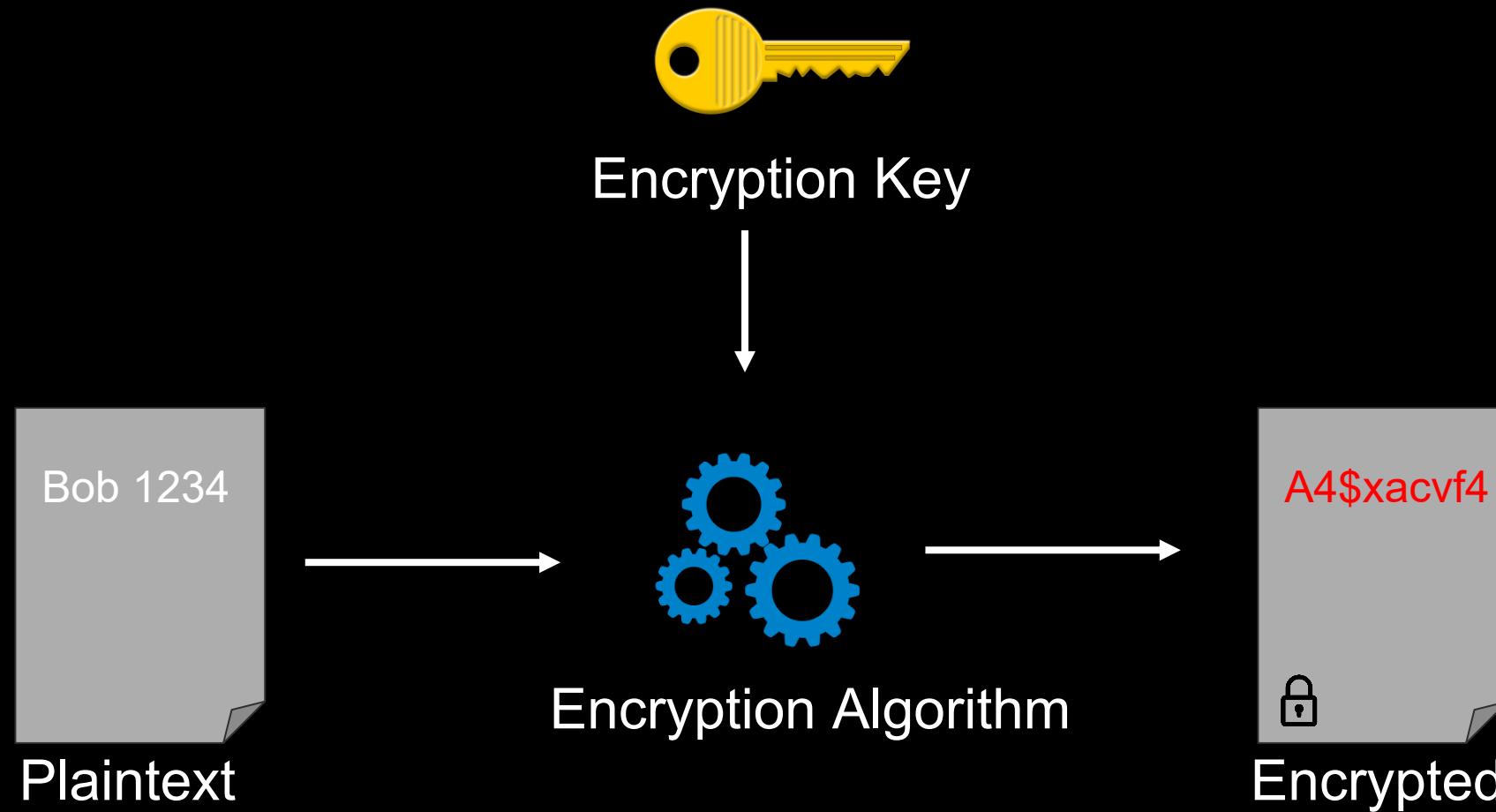
The level of configured provisioned throughput for the table was exceeded. Consider increasing your provisioning level with the UpdateTable API. (Click for details)

▼ DynamoDB (Client Response)

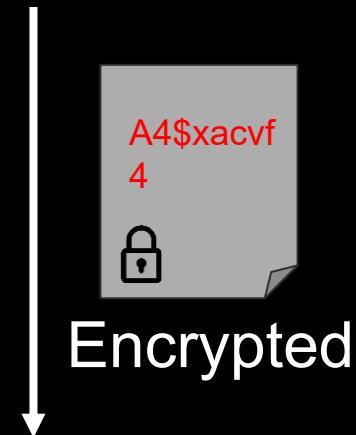
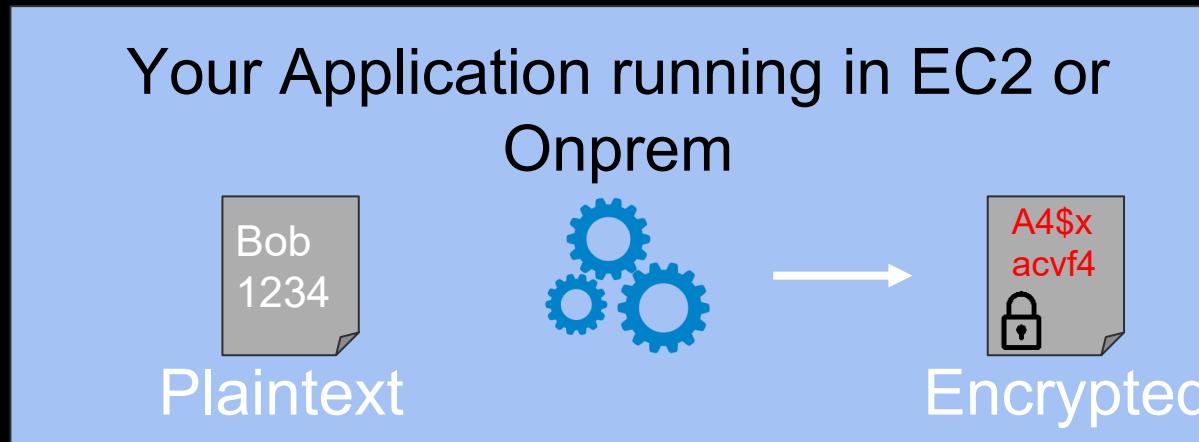
| | | | | | | | | | | | | | | | | | |
|--|---|--------|---|-----|-----------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|-------------|-------------|-------------|
| myapi-dev.us-west-2.elasticbeanstalk.com | - | 208 ms | ✓ | [] | 0 - 100ms | 100 - 200ms | 200 - 300ms | 300 - 400ms | 400 - 500ms | 500 - 600ms | 600 - 700ms | 700 - 800ms | 800 - 900ms | 900 - 1.0s | 1.0s - 1.1s | 1.1s - 1.2s | 1.2s - 1.2s |
| catalog.myapi.us-west-2.elasticbeanstalk.com | - | 281 ms | ✓ | [] | 0 - 100ms | 100 - 200ms | 200 - 300ms | 300 - 400ms | 400 - 500ms | 500 - 600ms | 600 - 700ms | 700 - 800ms | 800 - 900ms | 900 - 1.0s | 1.0s - 1.1s | 1.1s - 1.2s | 1.2s - 1.2s |
| catalog.myapi.us-west-2.elasticbeanstalk.com | - | 194 ms | ! | [] | 0 - 100ms | 100 - 200ms | 200 - 300ms | 300 - 400ms | 400 - 500ms | 500 - 600ms | 600 - 700ms | 700 - 800ms | 800 - 900ms | 900 - 1.0s | 1.0s - 1.1s | 1.1s - 1.2s | 1.2s - 1.2s |
| catalog.myapi.us-west-2.elasticbeanstalk.com | - | 233 ms | ✓ | [] | 0 - 100ms | 100 - 200ms | 200 - 300ms | 300 - 400ms | 400 - 500ms | 500 - 600ms | 600 - 700ms | 700 - 800ms | 800 - 900ms | 900 - 1.0s | 1.0s - 1.1s | 1.1s - 1.2s | 1.2s - 1.2s |

Understanding Encryption at Rest & Client/Server Side Encryption

Encryption Flow



Client Side Encryption



Server Side Encryption

Your Application running in EC2 or Onprem

Bob
1234

Plaintext

Bob
1234

Plaintext

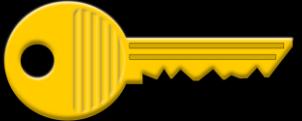
HTTPS

AWS Storage

A4\$X
acvf4
🔒

Encrypted

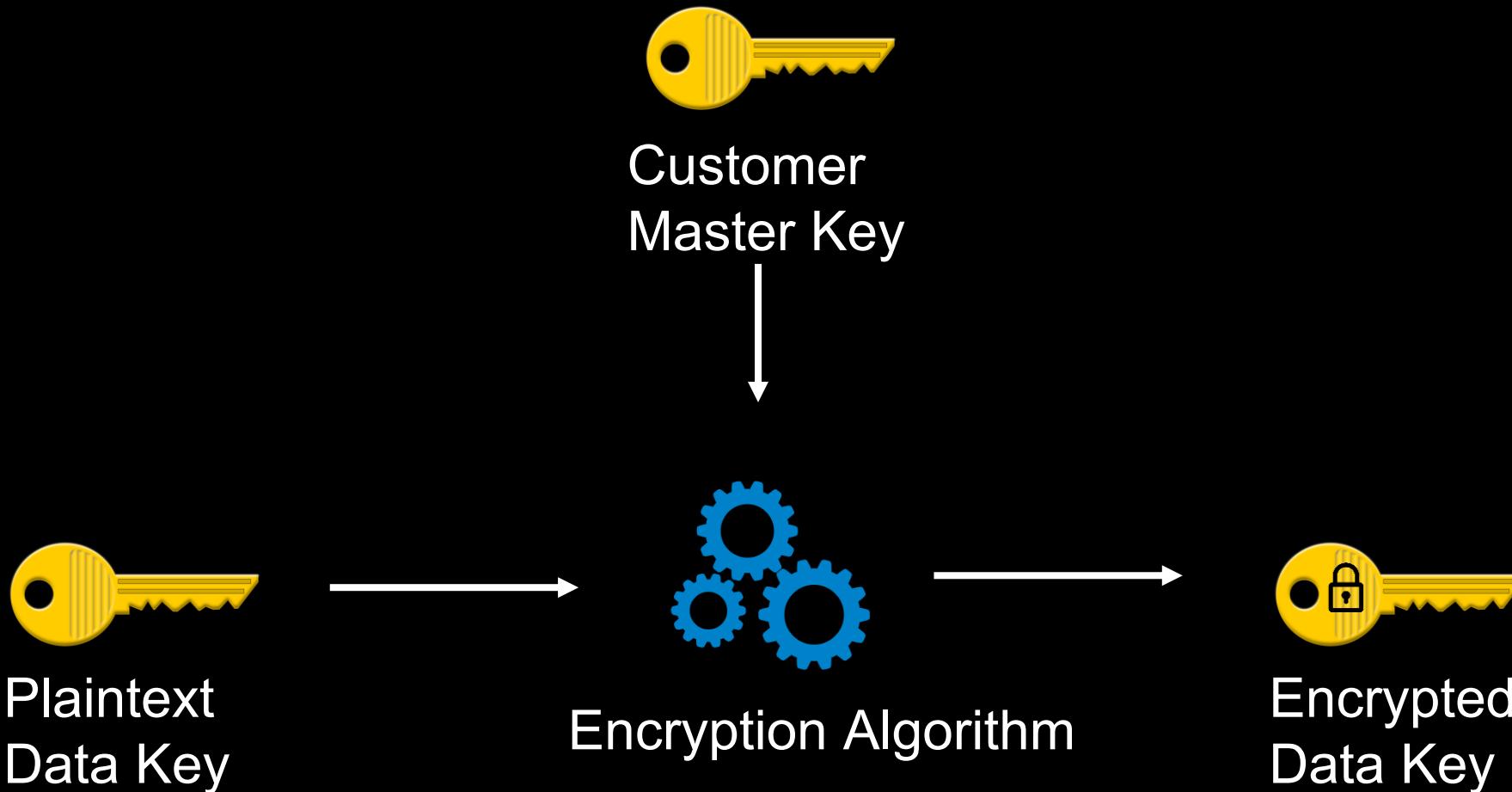
Managing Key Yourselves



Encryption Key

- Keys need to be rotated periodically
- Making it harder to obtain the key for intruders

Envelope Encryption



Managing Key Yourselves



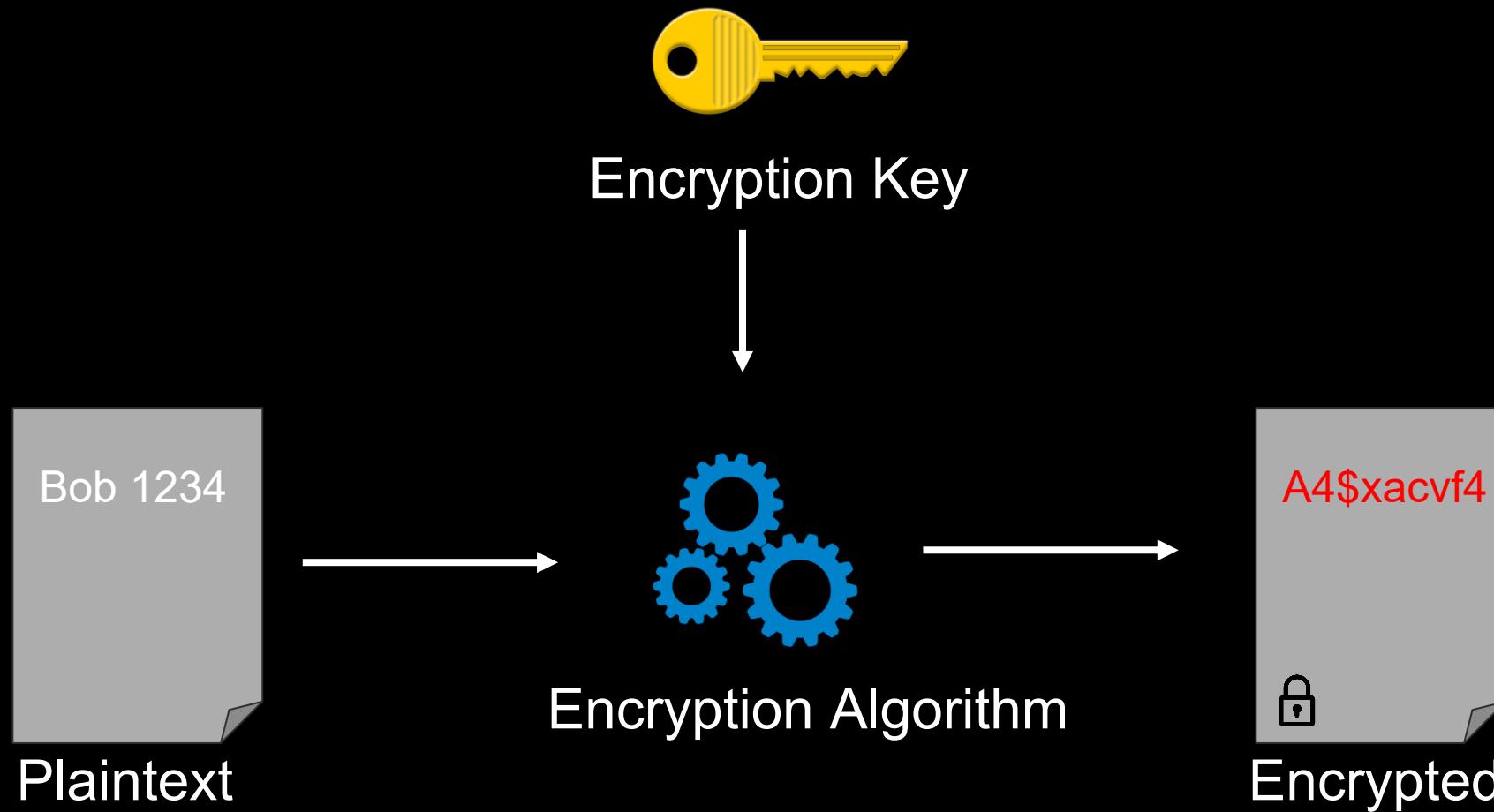
Encryption Key

- Keys need to be rotated periodically
- Making it harder to obtain the key for intruders
- Track and log your keys usage, detect anomaly

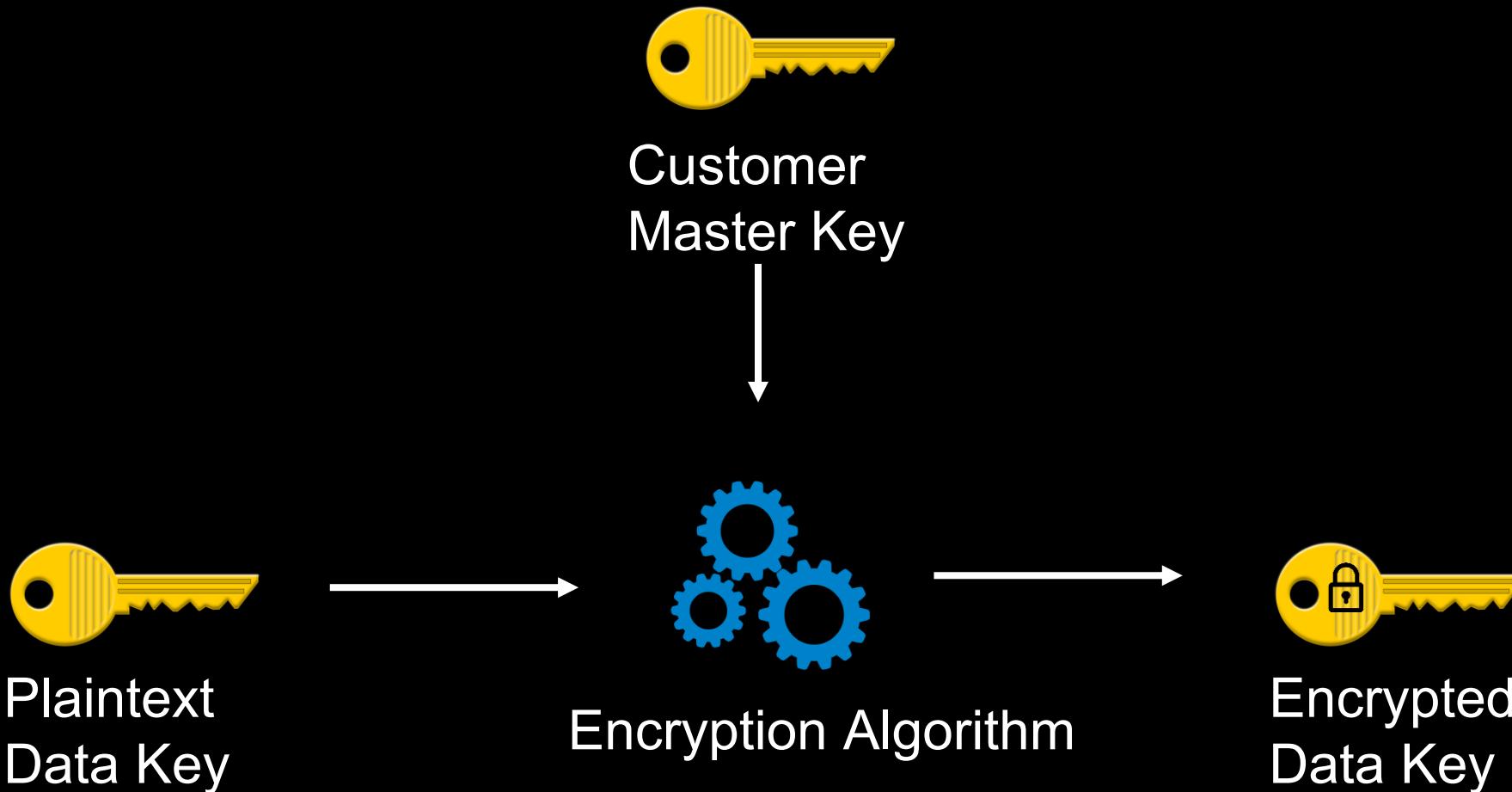
AWS KMS (Key Management System)

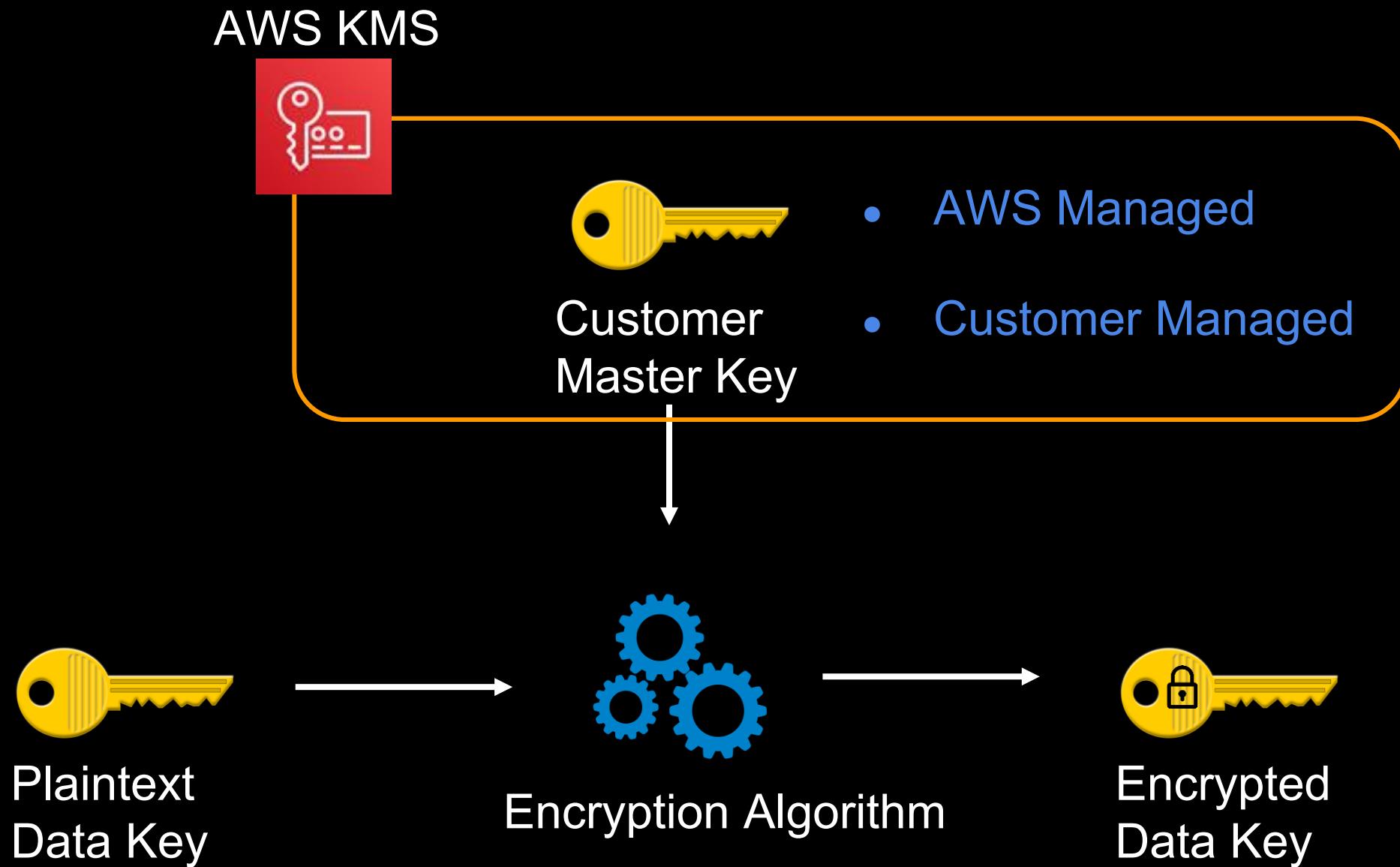
- Fully Managed
- Centralized Key Management
- Integration with AWS Services
- Built in Auditing
- Secure and Compliant

Encryption Flow



Envelope Encryption





AWS Managed CMK

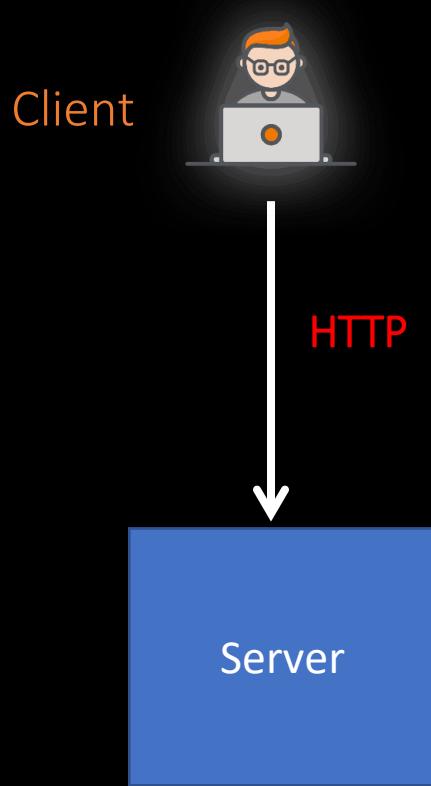
- Identified by *aws/servicename*
- AWS generated
- Can't be deleted
- Can't be baked into custom roles
- Rotated once every 3 years automatically

Customer Managed CMK

- Can be given any name
- Customer created
- Can be deleted/enabled/disabled
- Can be baked into custom roles
- Rotated once a year automatically or manually

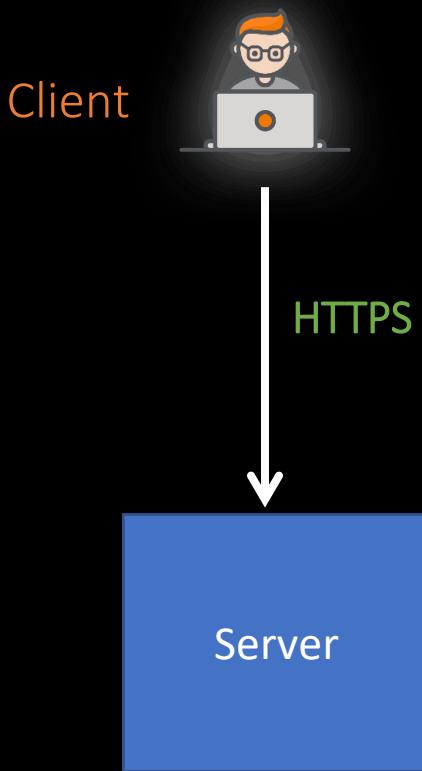
Security at Transit

Data in Transit



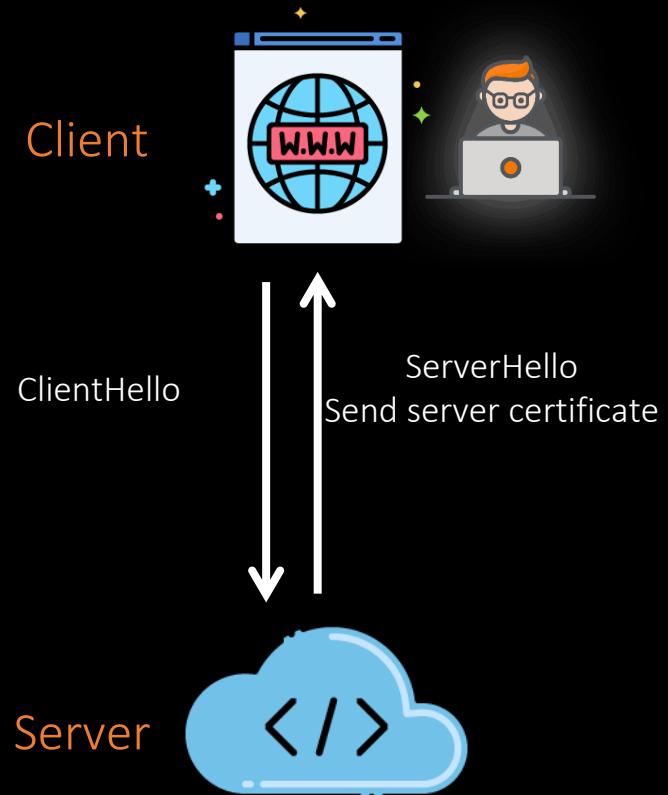
- Hyper Text Transfer Protocol
- All information is sent in clear text
- Vulnerable to attack
- Not used in real world systems

Data in Transit



- Hyper Text Transfer Protocol Secure
- All information is encrypted
- Uses one of the two protocols:
 - SSL (Secure Socket Layer)
 - TLS (Transport Layer Security)
 - MTLS (Mutual TLS)
 - TLS is faster, newer, and built on SSL

SSL/TLS Flow



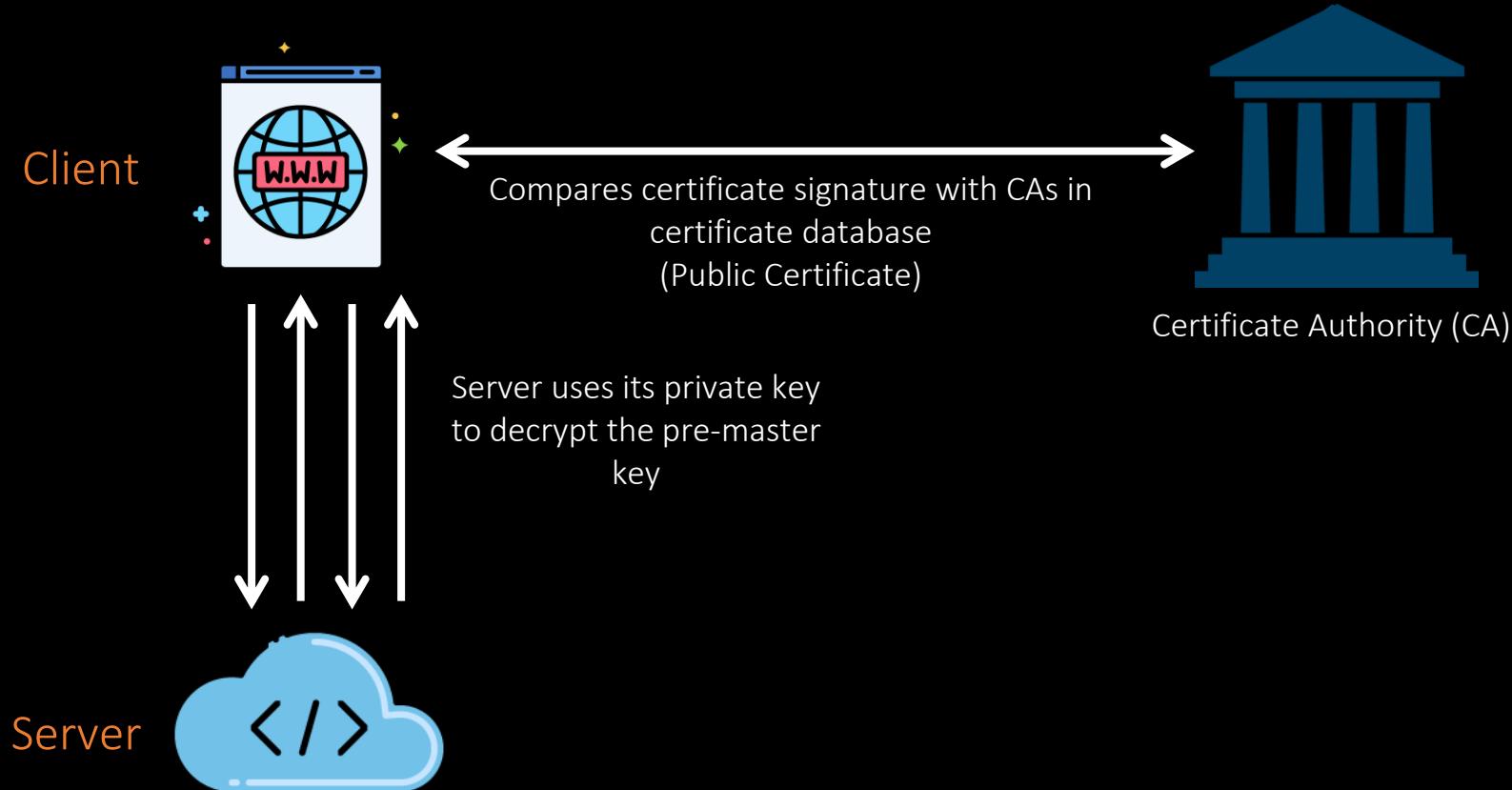
SSL/TLS Flow



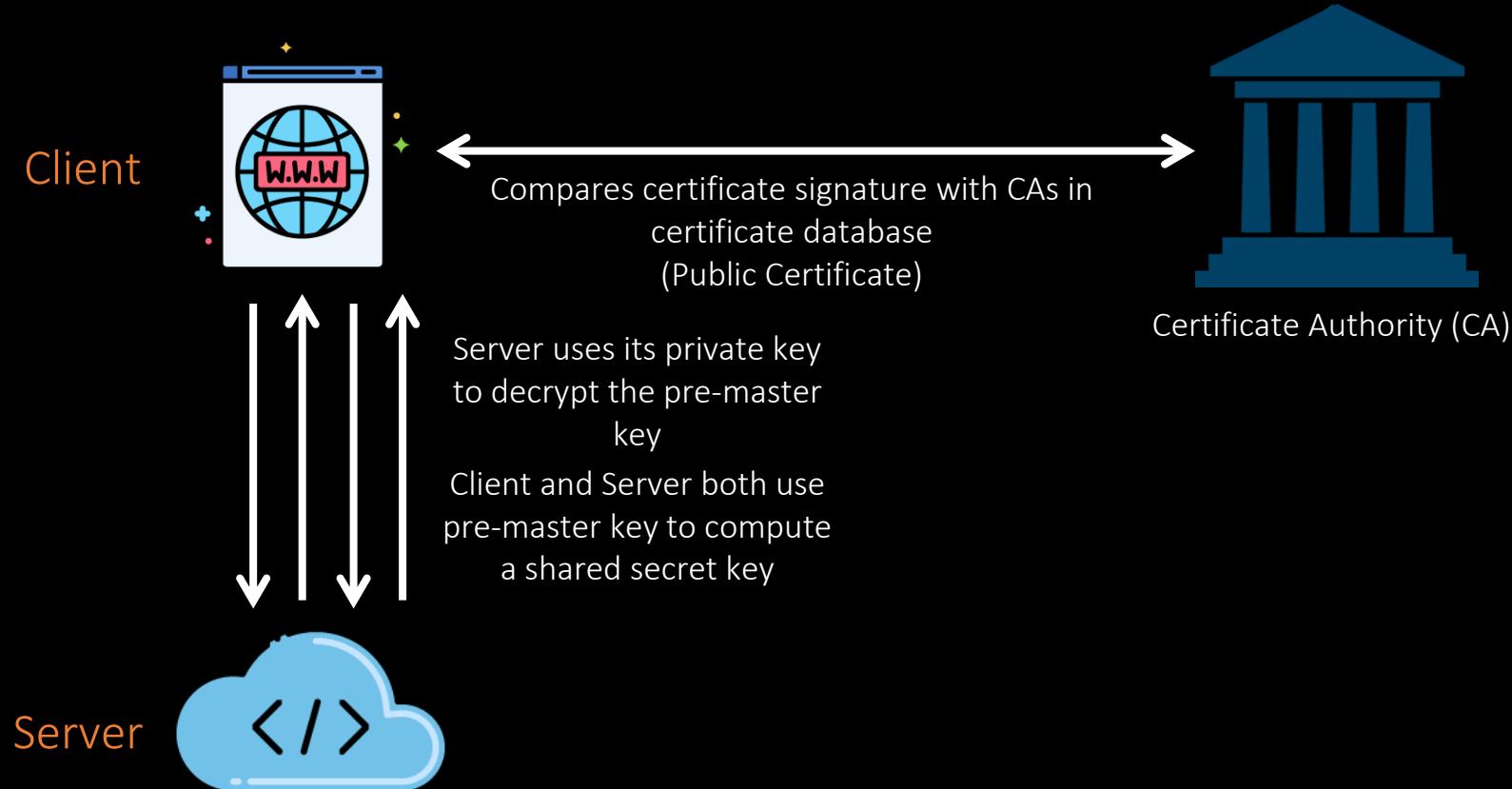
SSL/TLS Flow



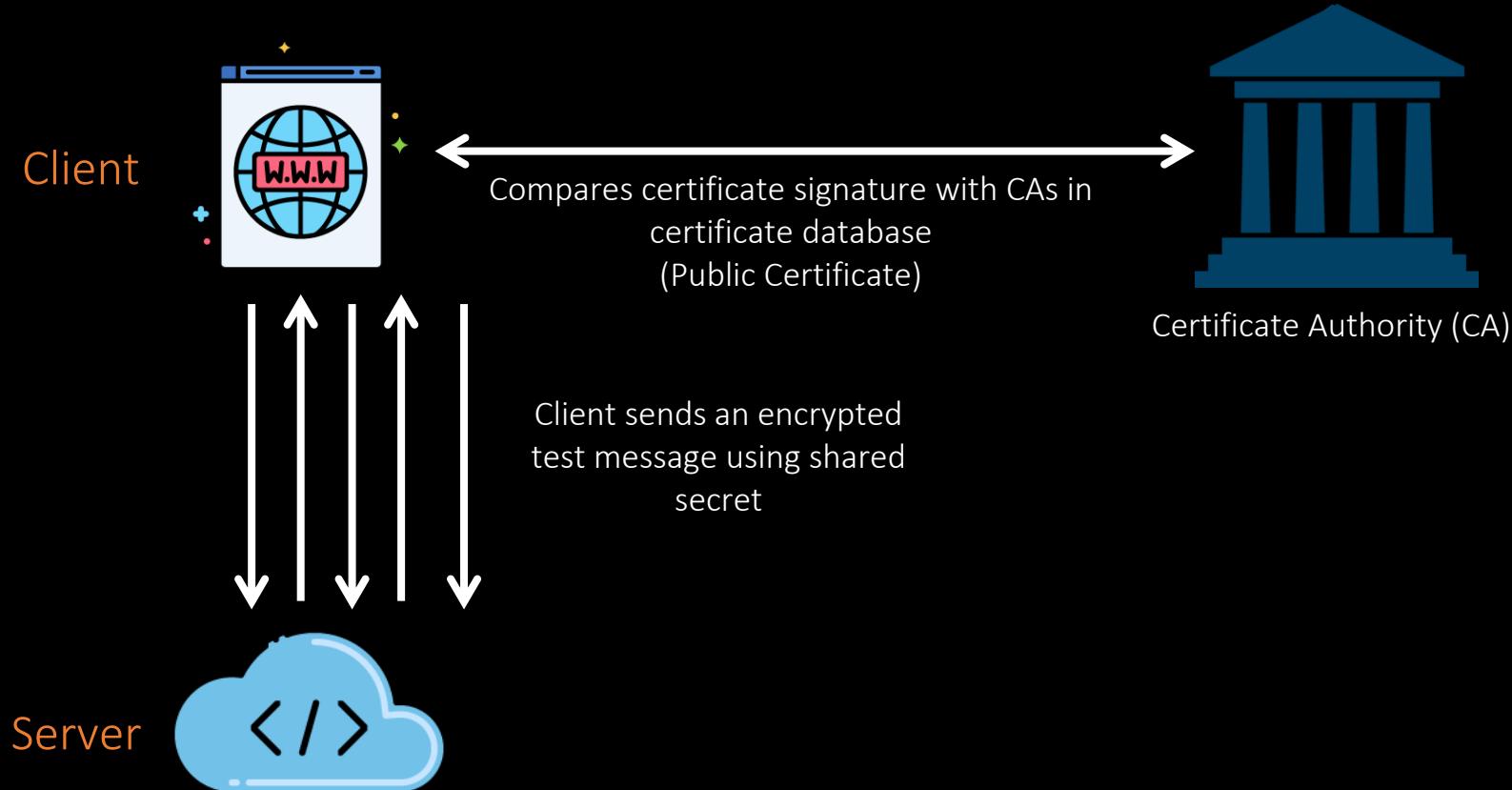
SSL/TLS Flow



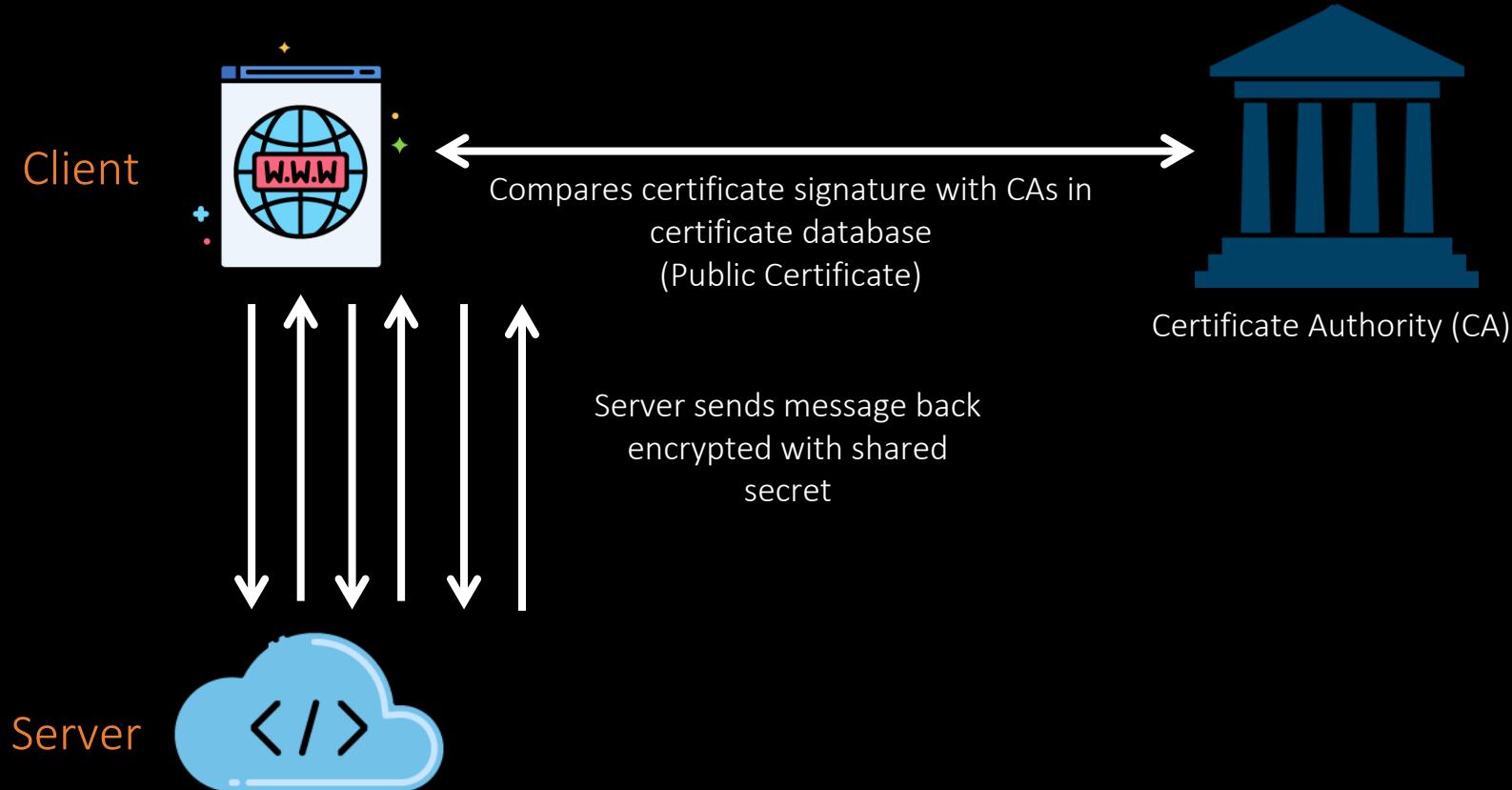
SSL/TLS Flow



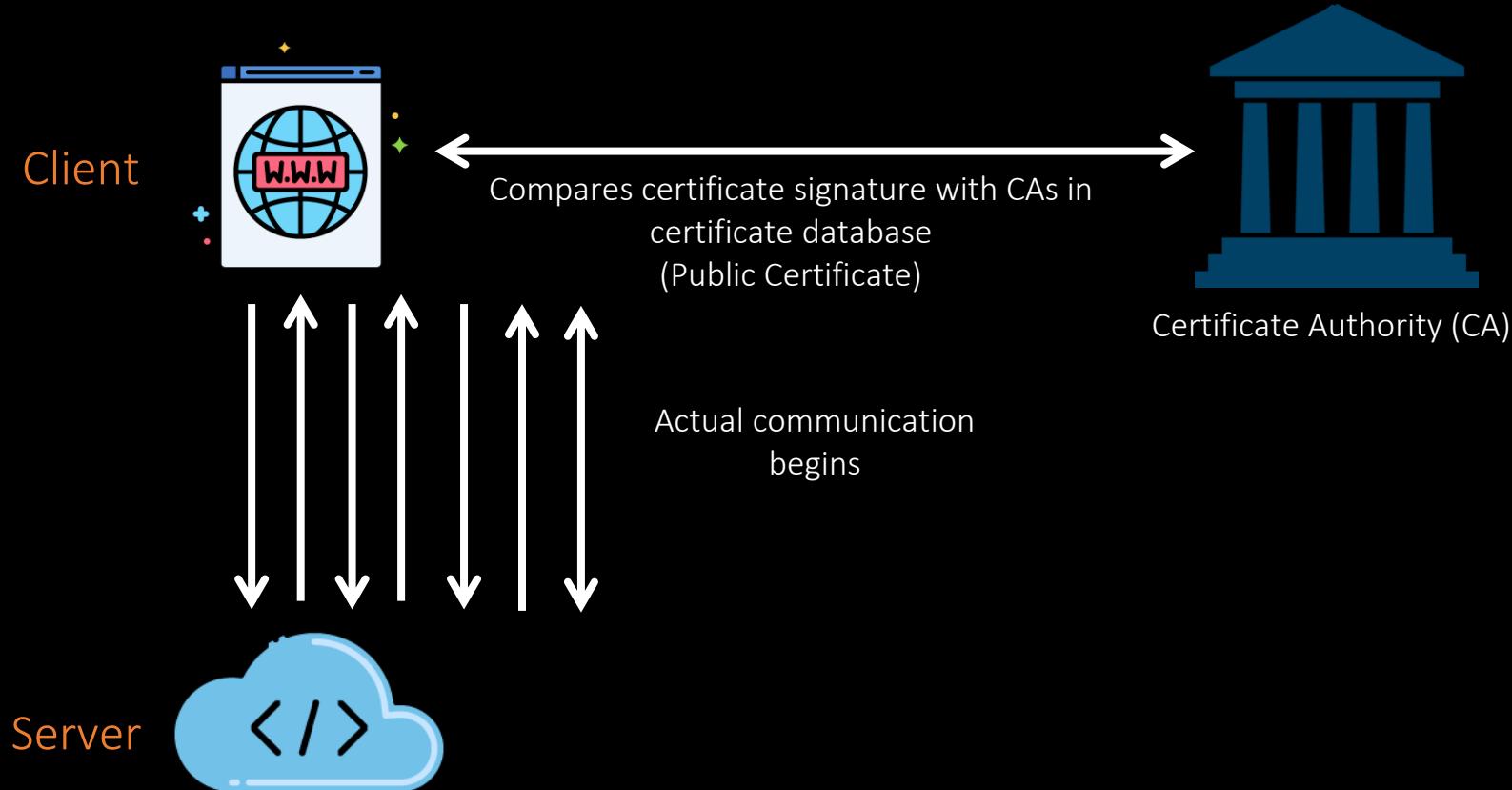
SSL/TLS Flow



SSL/TLS Flow



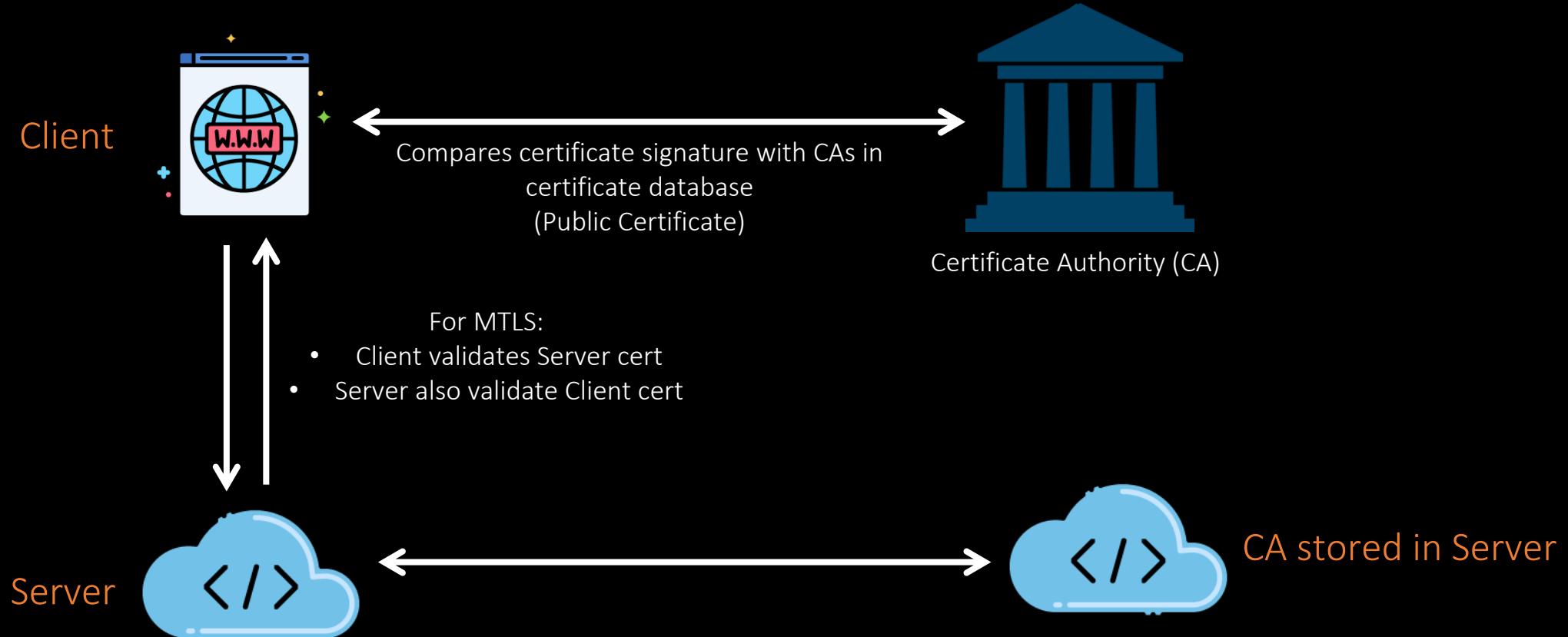
SSL/TLS Flow



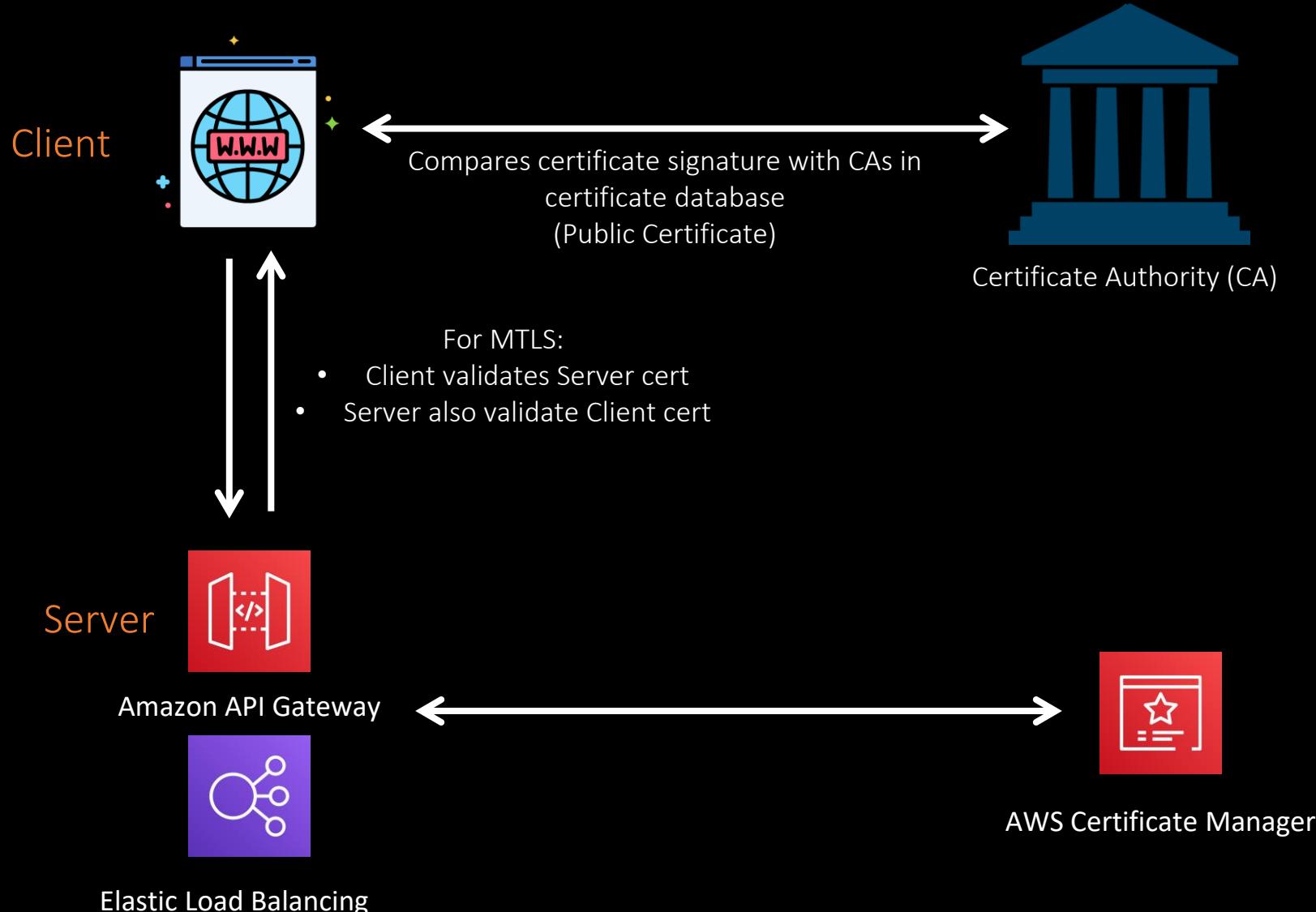
Mutual TLS



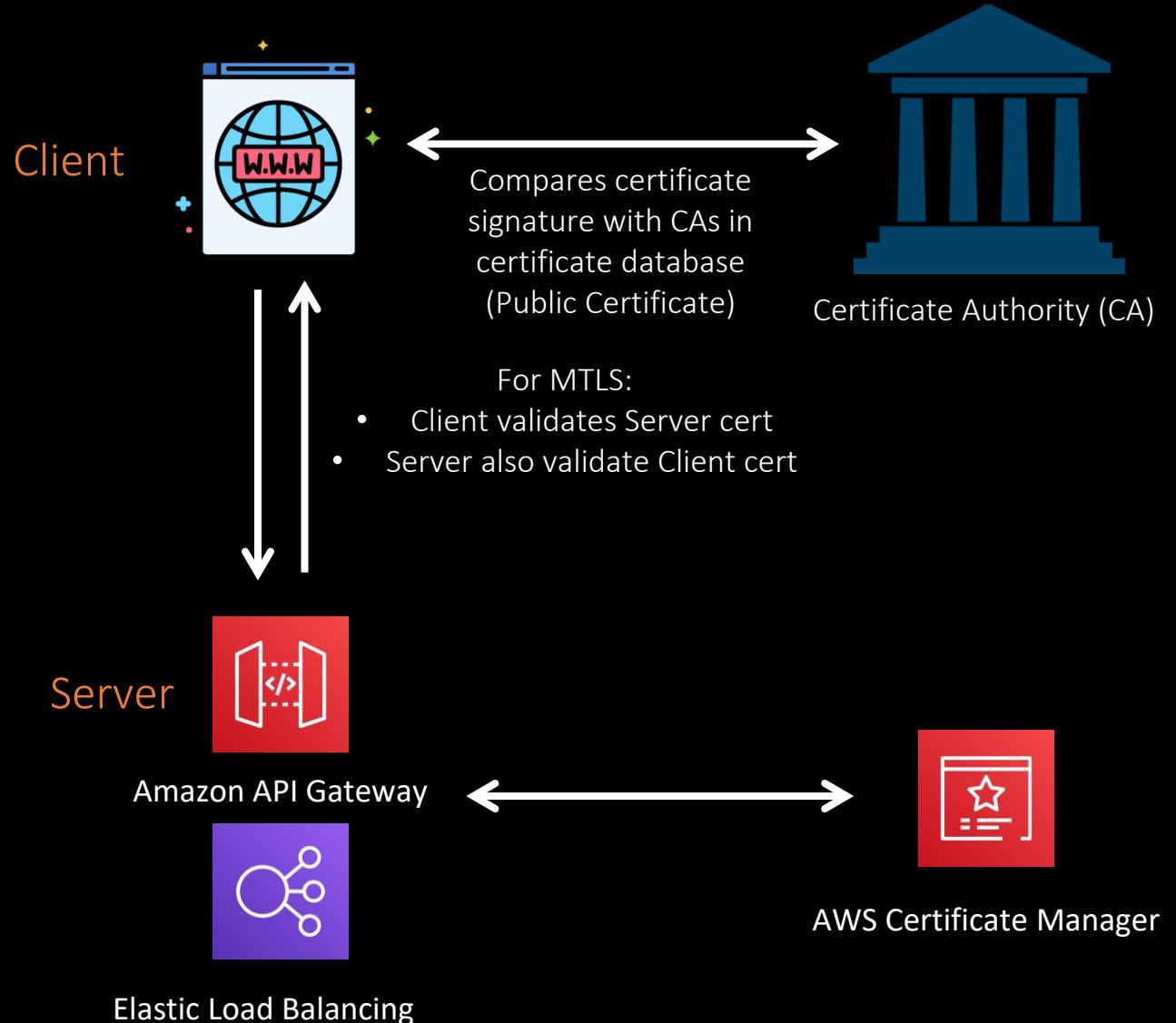
Mutual TLS



Mutual TLS in AWS



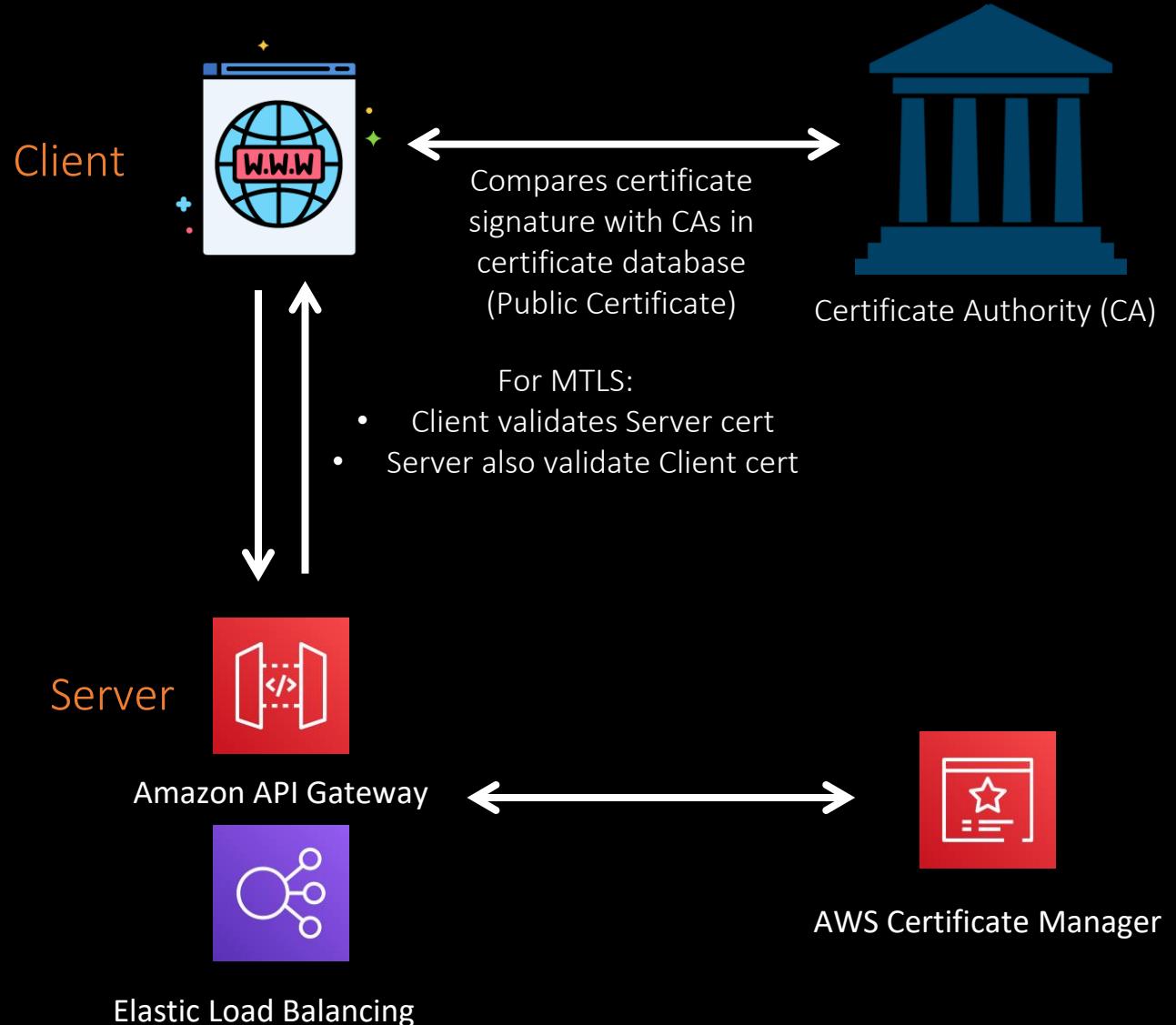
Mutual TLS in AWS



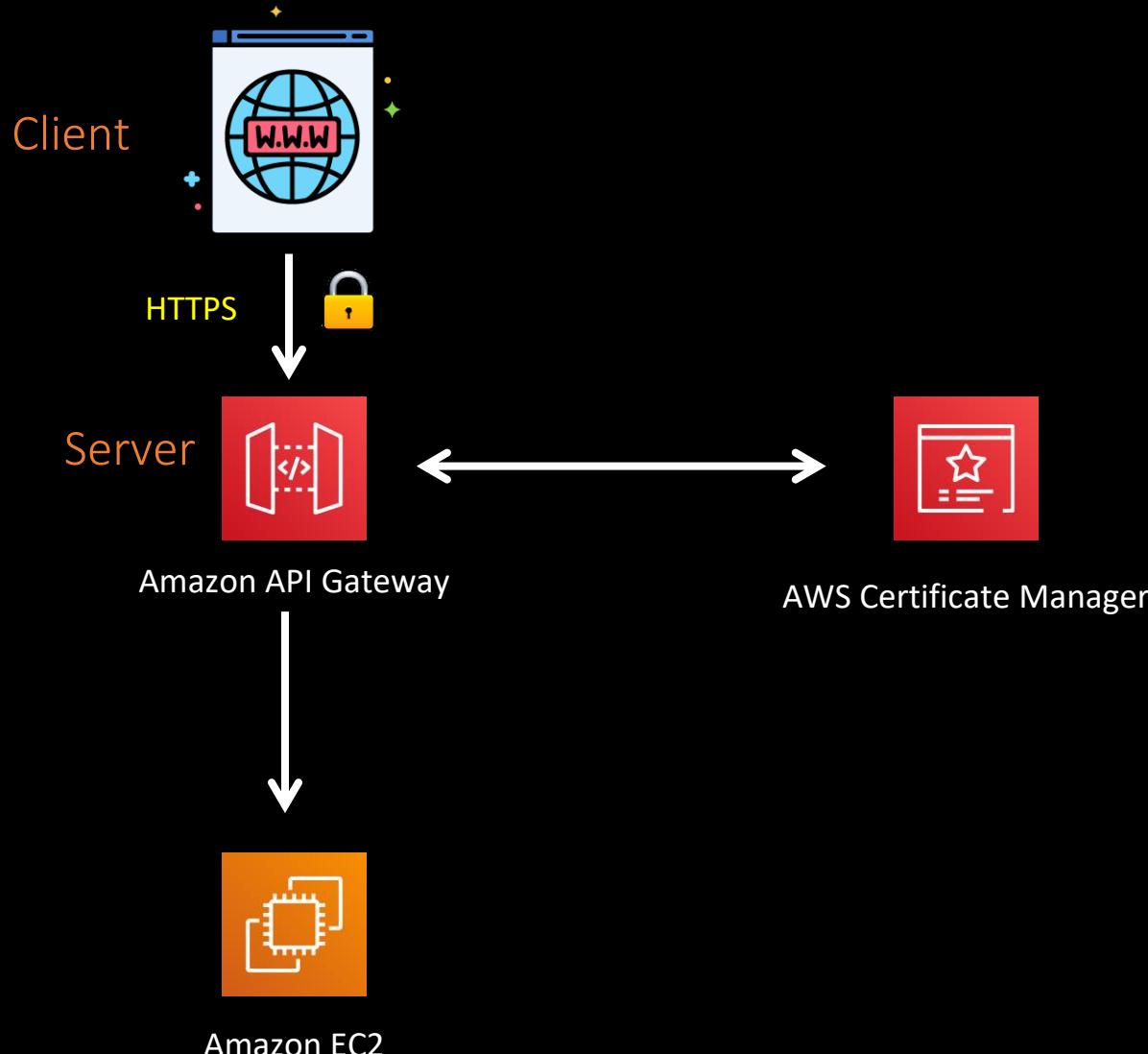
- **MTLS is used for B2B**
- **TLS is used with thin clients (web browsers)**

Real World TLS with ALB, NLB, API Gateway

Mutual TLS in AWS

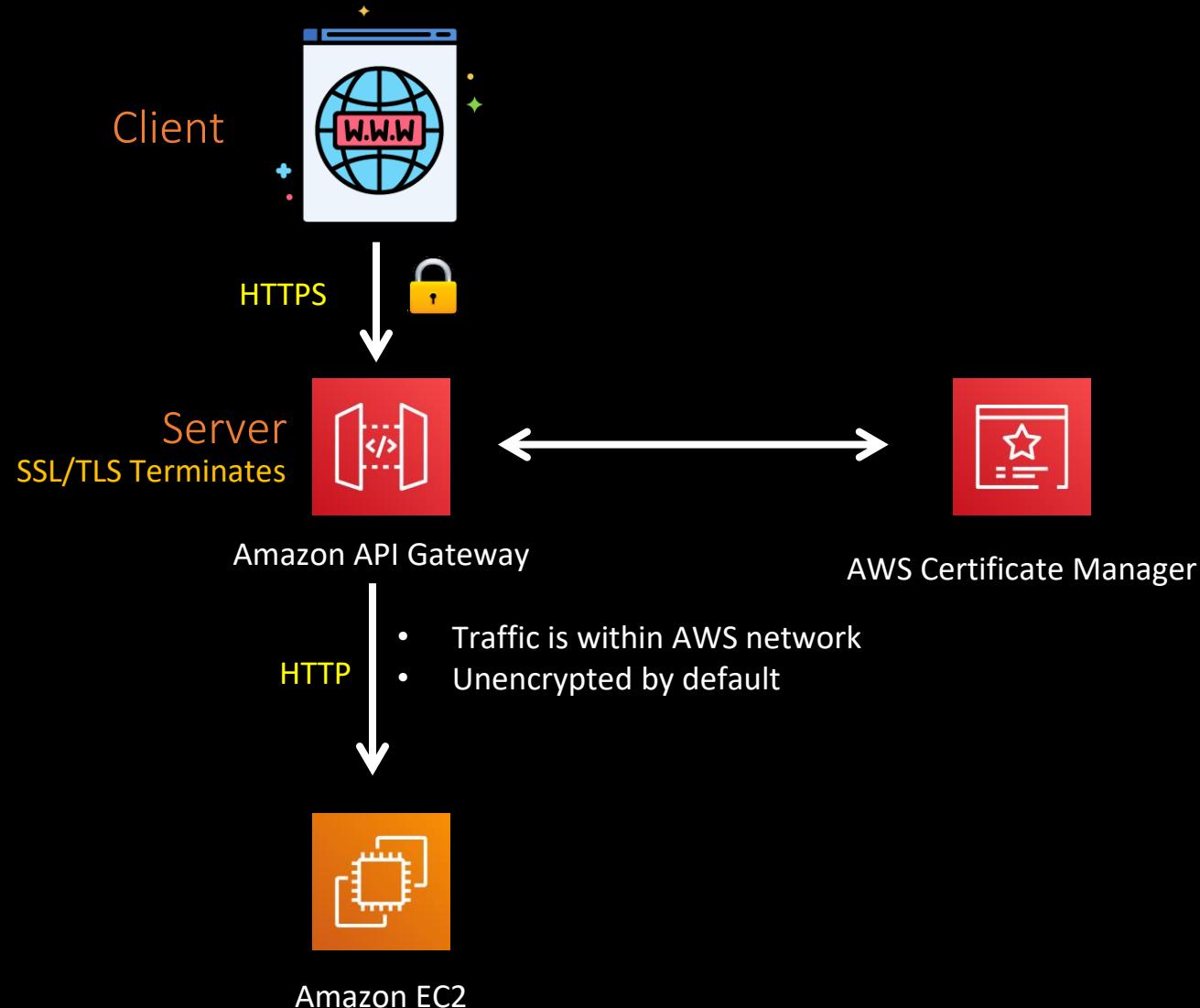


TLS with API Gateway

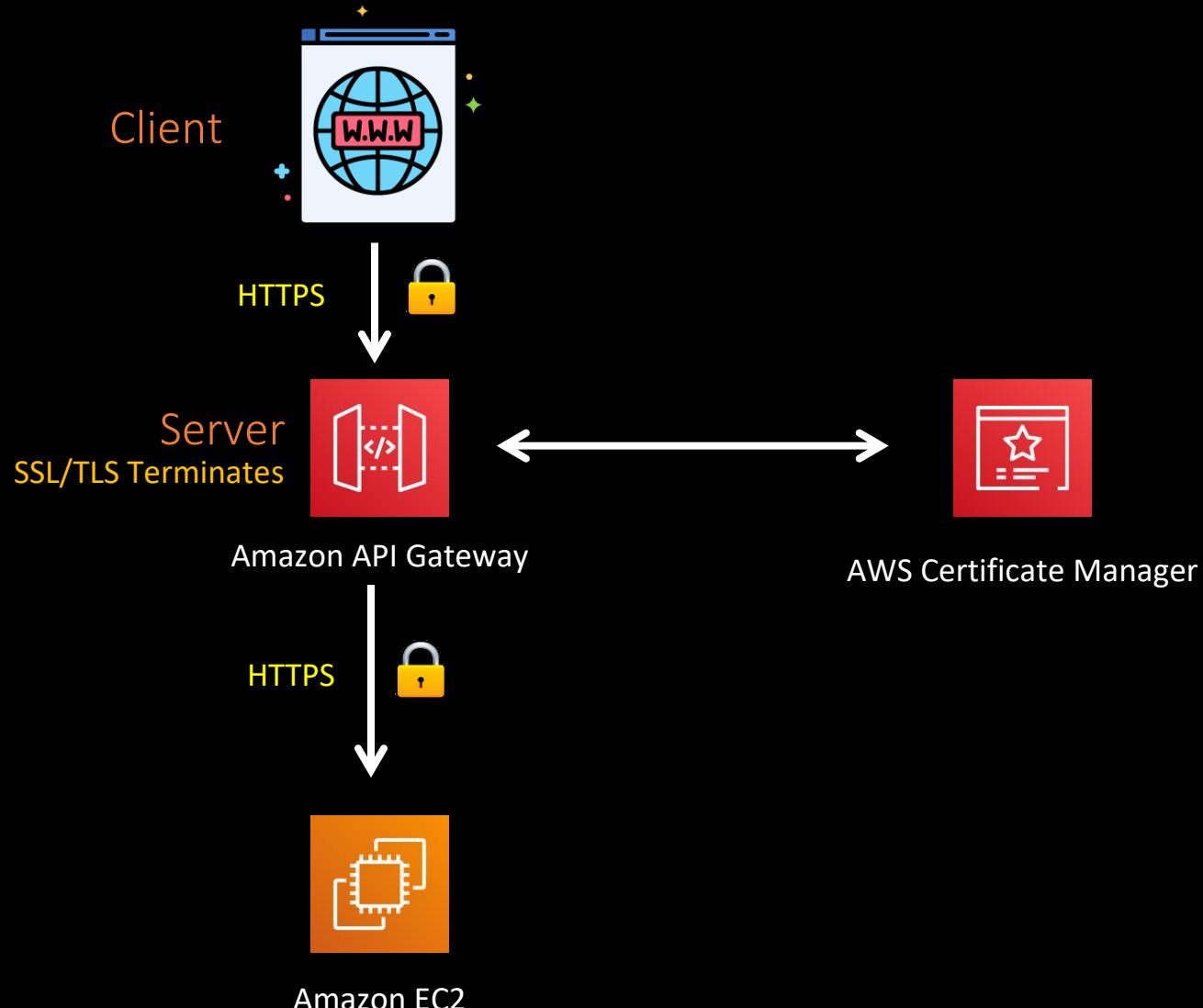


- API Gateway must have HTTPS
- By default, API Gateway will use AWS default cert
- With custom domain, you can bring in your own cert

TLS with API Gateway

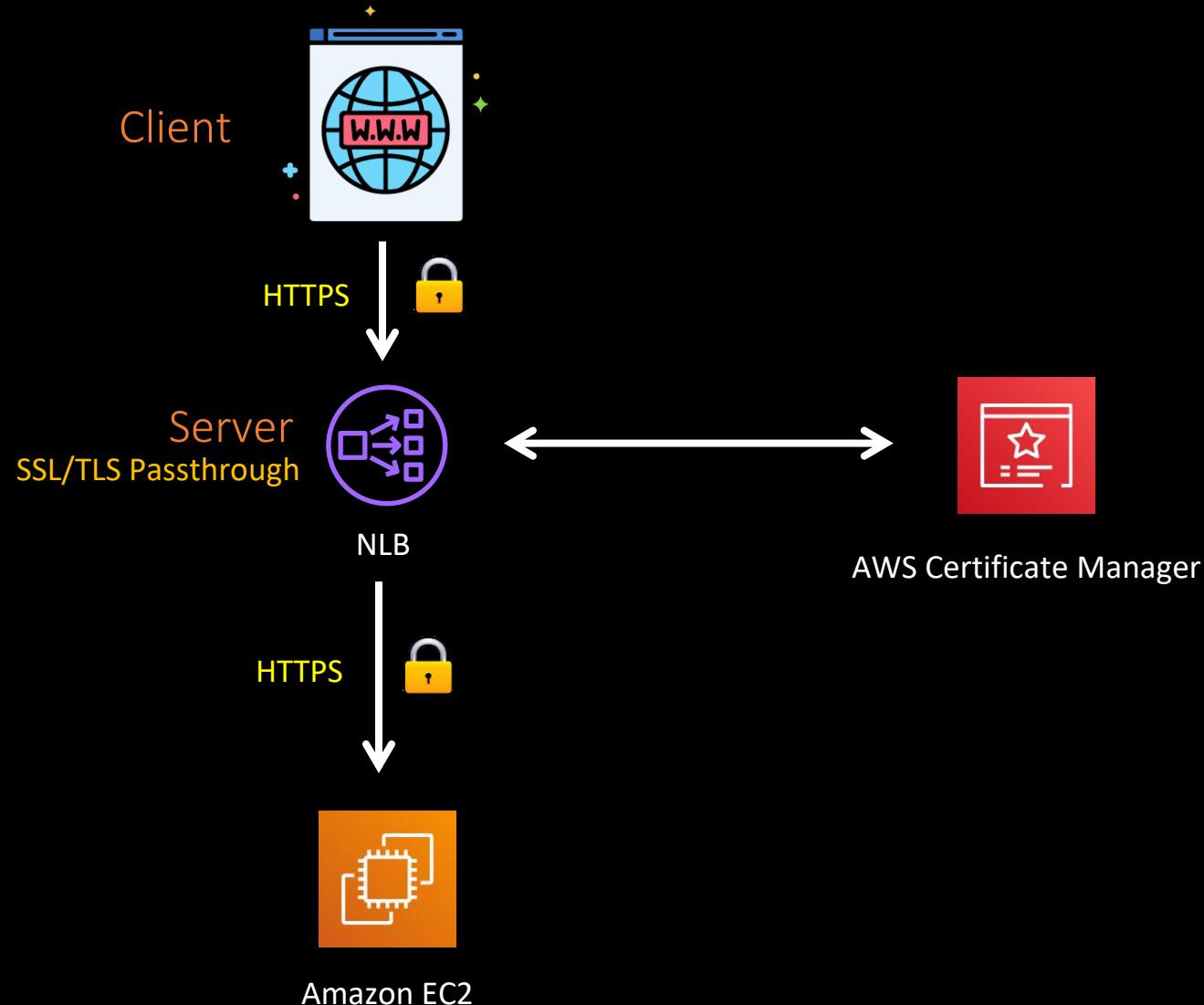


TLS with API Gateway



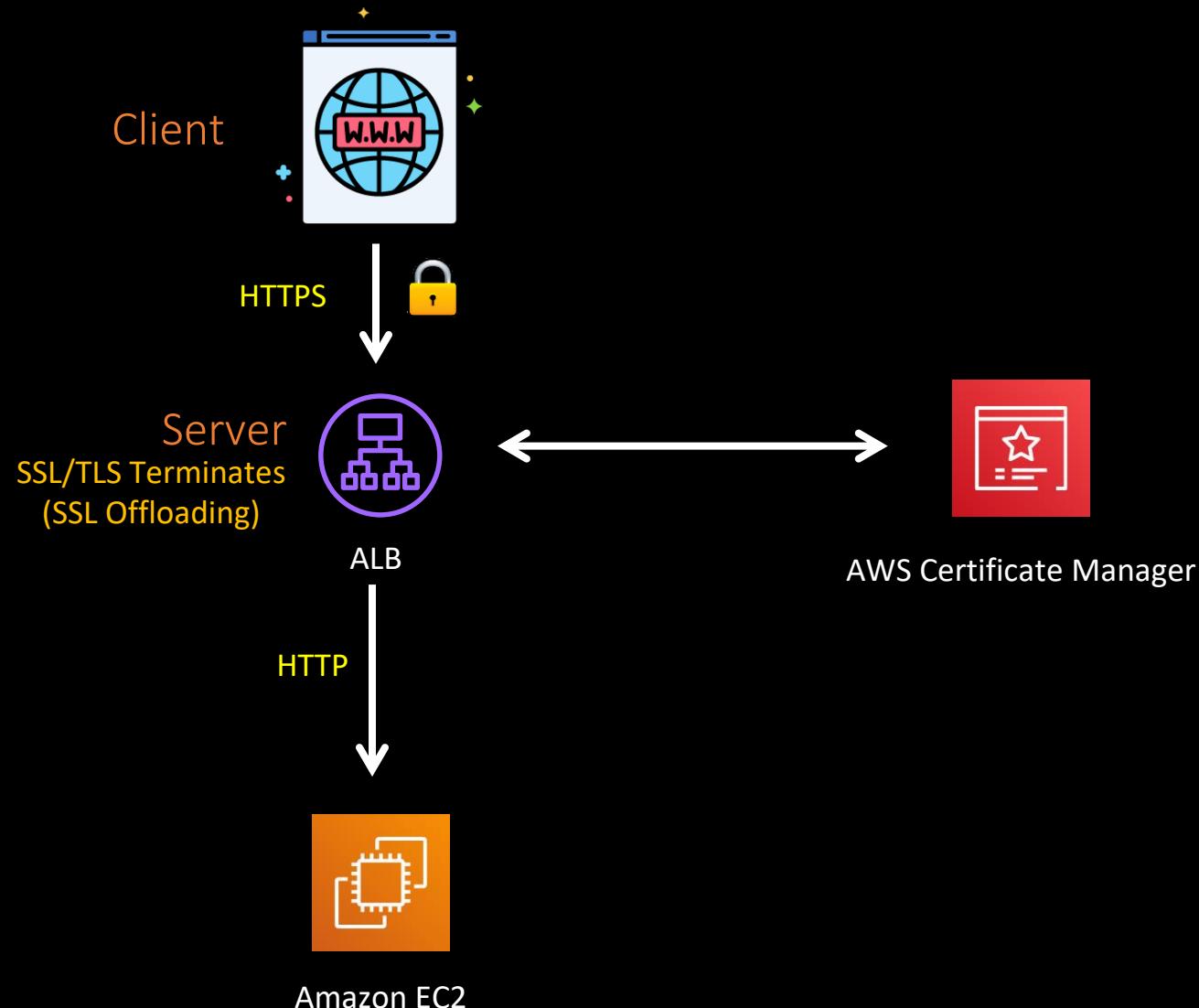
- API Gateway can create an SSL cert for backend
- Backend server needs to validate the cert

TLS with NLB



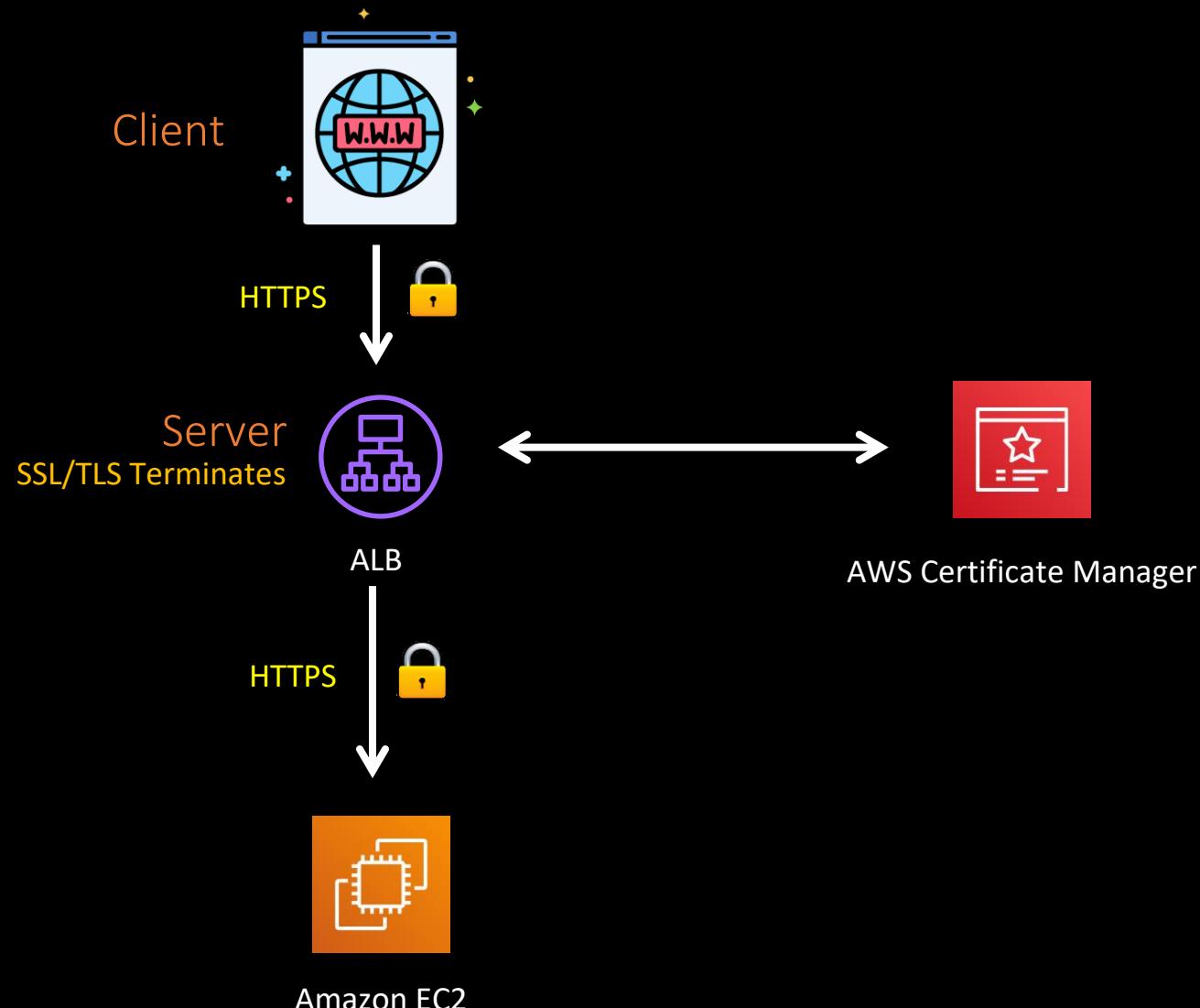
- SSL/TLS can NOT be terminated at NLB
- Backend server need to validate cert

TLS with ALB



- ALB can accept either HTTP or HTTPS traffic from client
- SSL/TLS will terminate at ALB
 - Backend traffic within AWS network

TLS with ALB

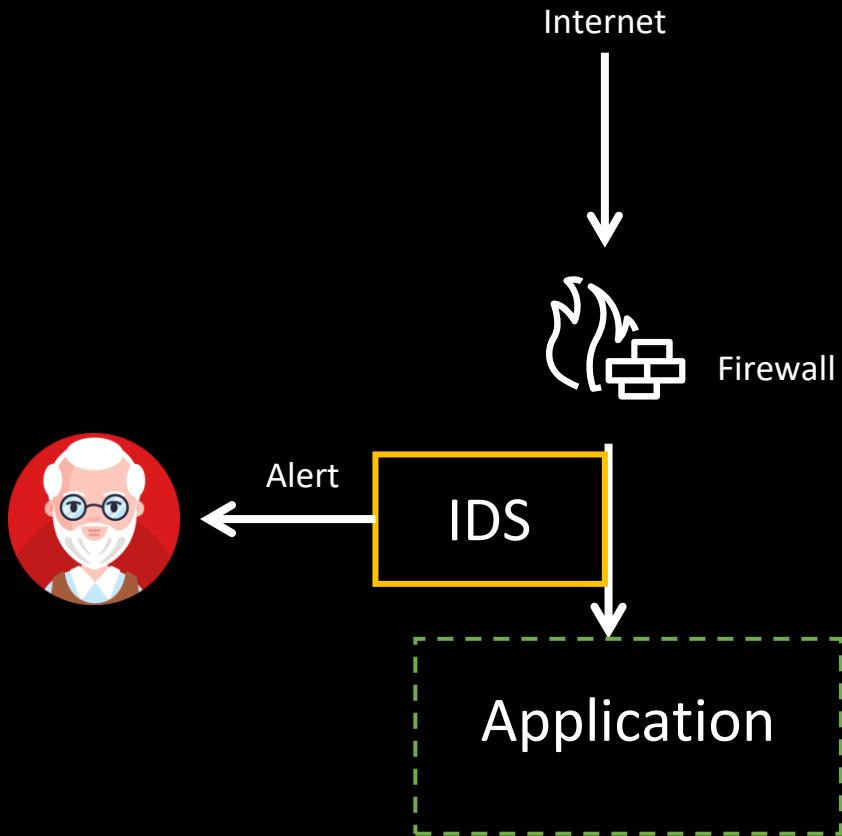


- ALB can have HTTPS to server if required

IDS/IPS Intrusion Detection/Prevention System

IDS

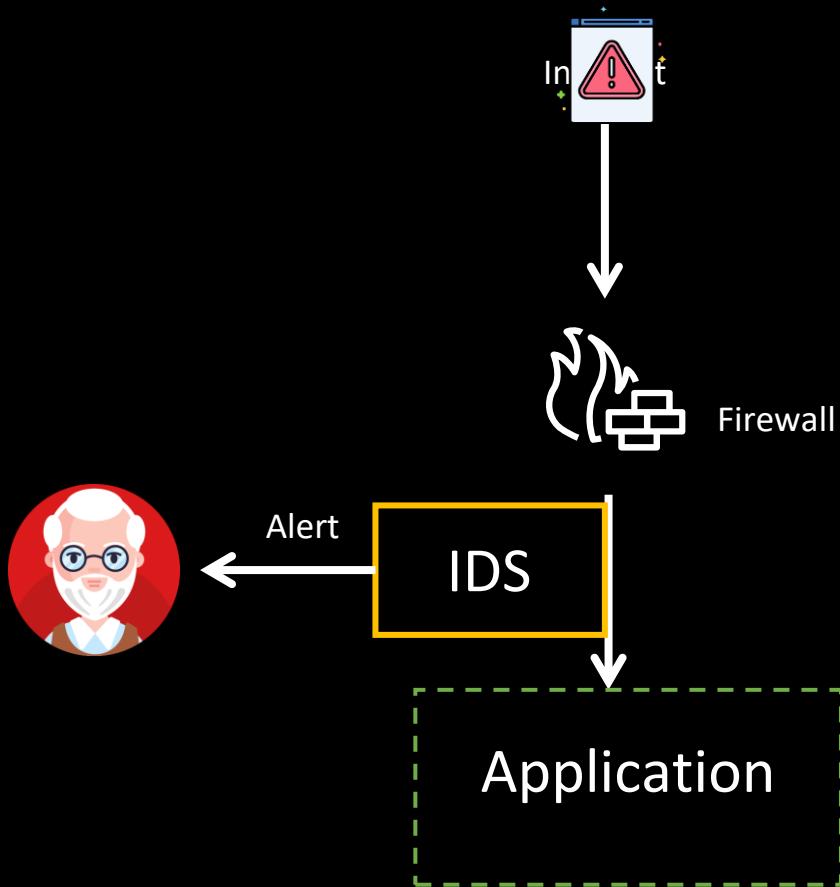
IPS



- Scans L3-L7 traffic
- Detects and sends alerts

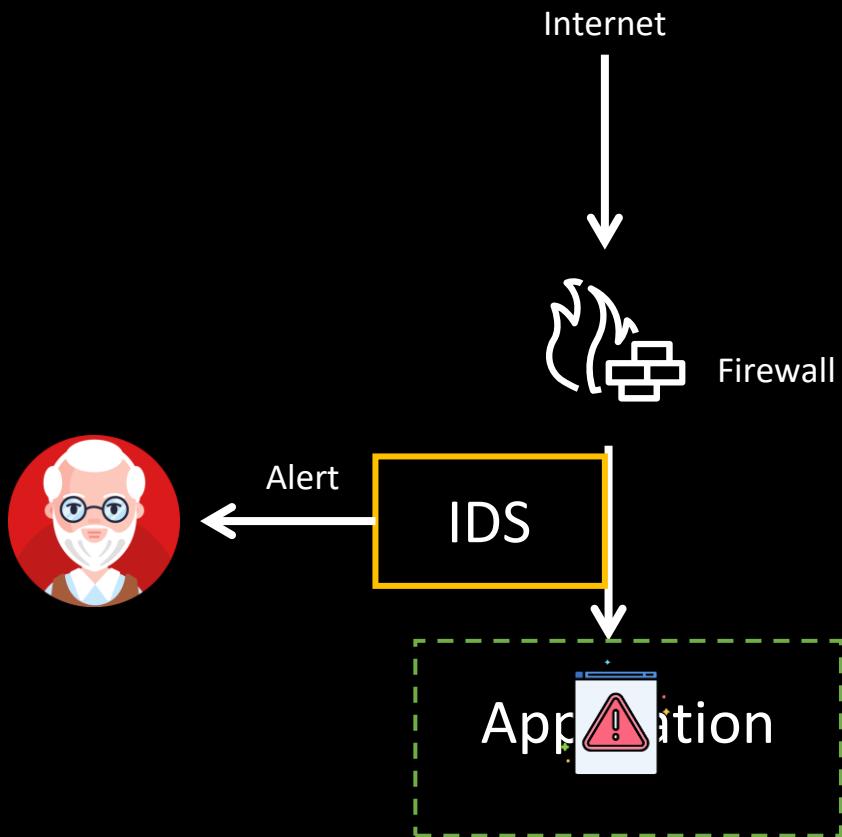
IDS

IPS



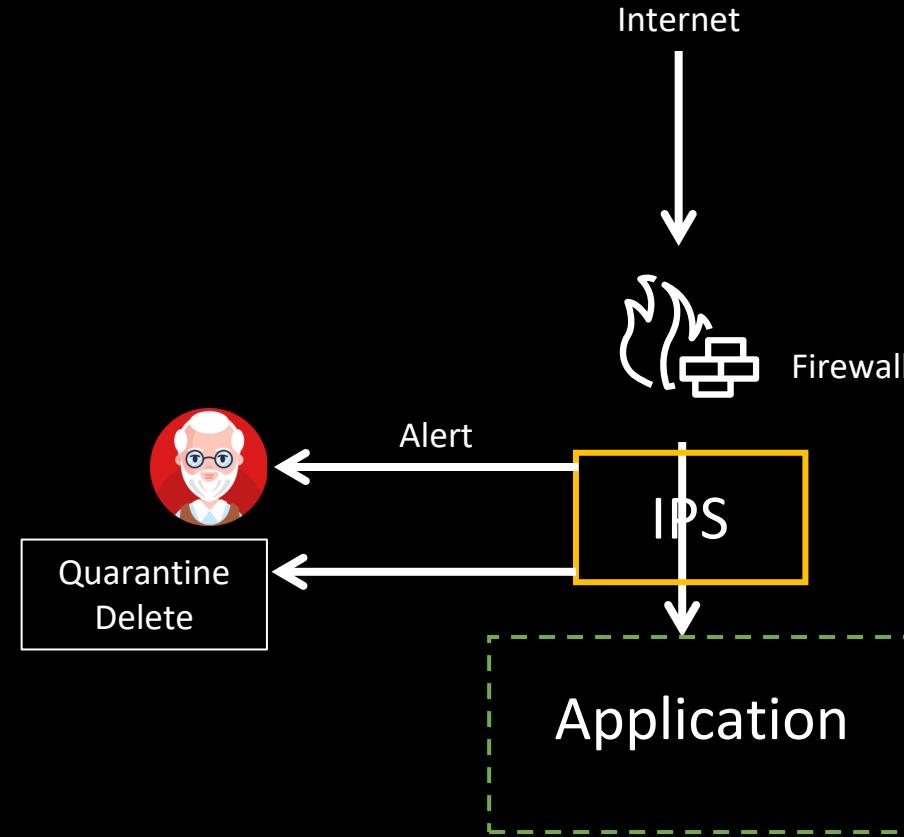
- Scans L3-L7 traffic
- Detects and sends alerts
- Does NOT prevent the traffic

IDS



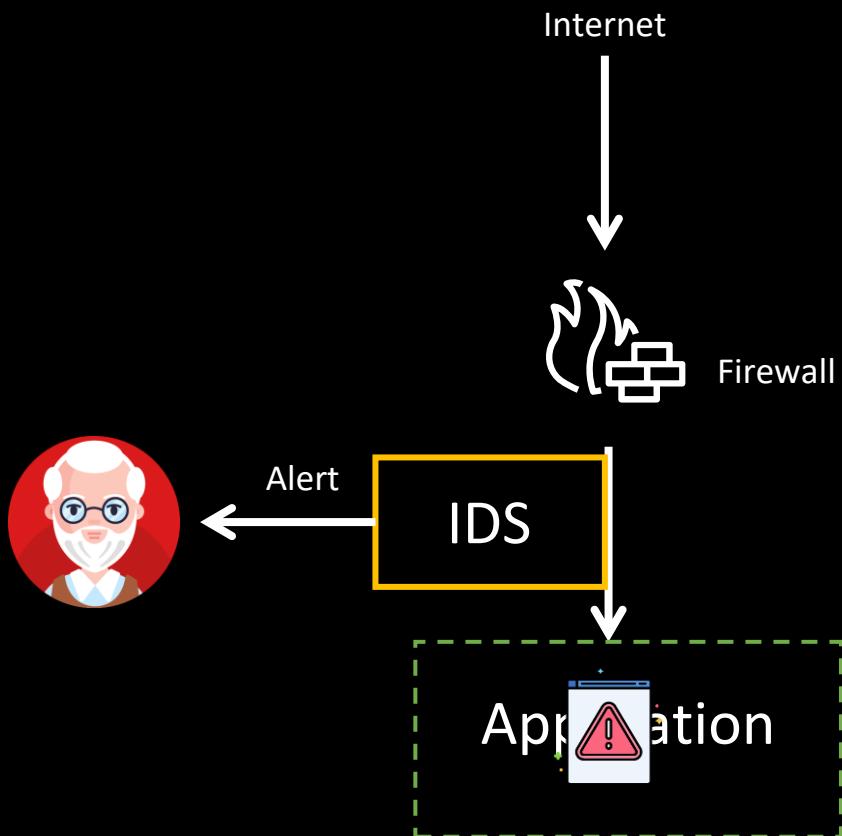
- Scans L3-L7 traffic
- Detects and sends alerts
- Does NOT prevent the traffic

IPS



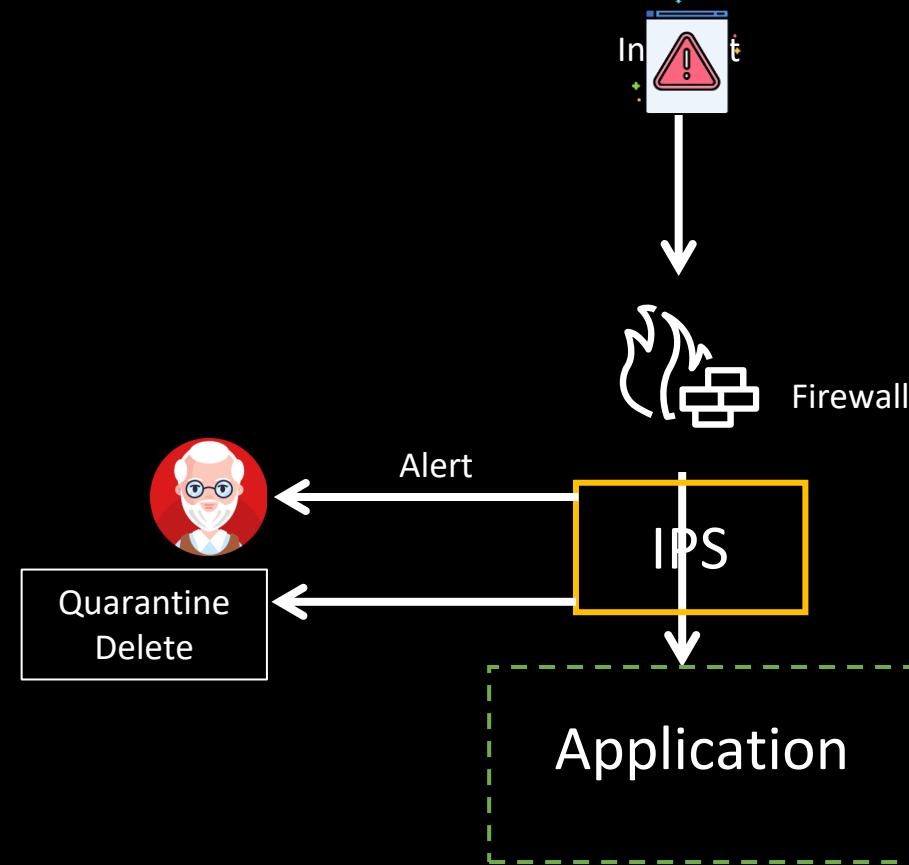
- Scans L3-L7 traffic
- Detects and sends alerts
- Prevents malicious traffic from reaching application

IDS



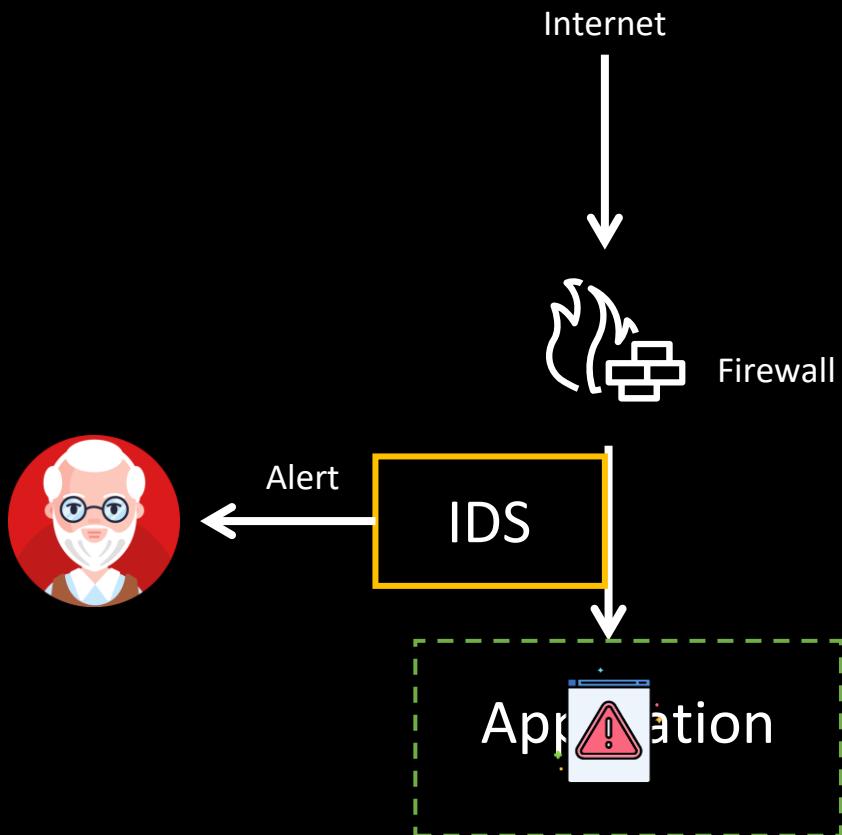
- Scans L3-L7 traffic
- Detects and sends alerts
- Does NOT prevent the traffic

IPS



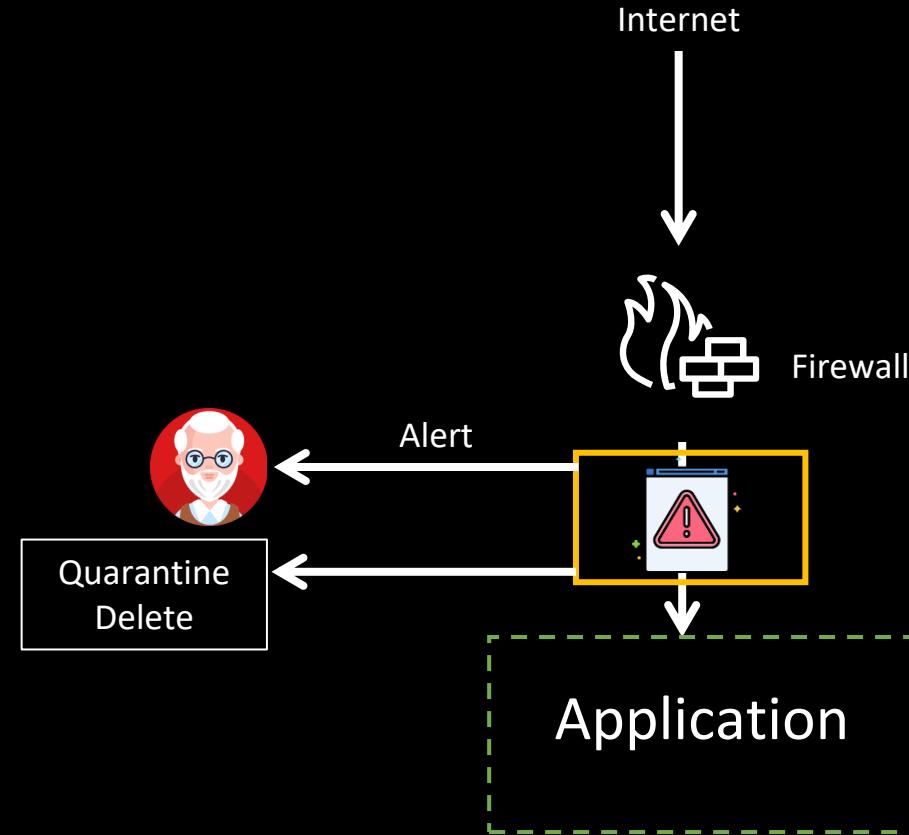
- Scans L3-L7 traffic
- Detects and sends alerts
- Prevents malicious traffic from reaching application

IDS



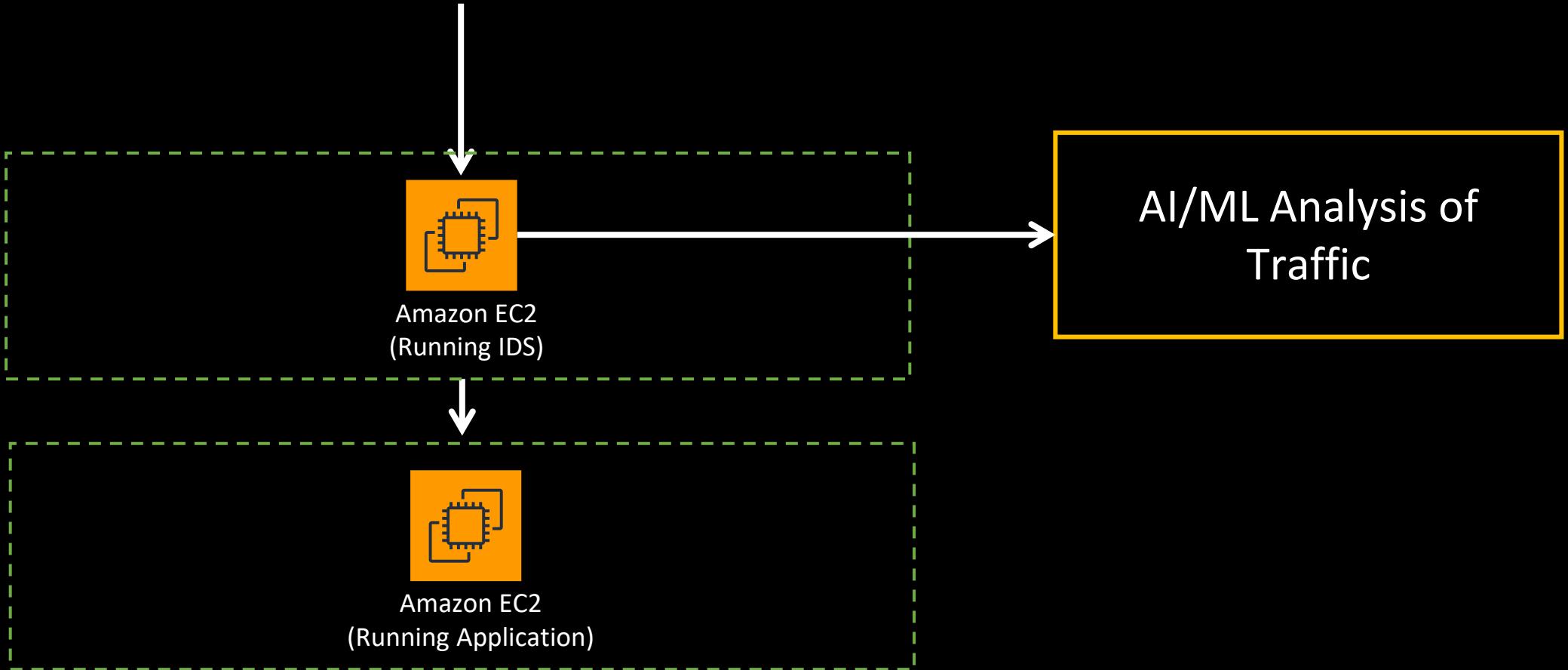
- Scans L3-L7 traffic
- Detects and sends alerts
- Does NOT prevent the traffic

IPS

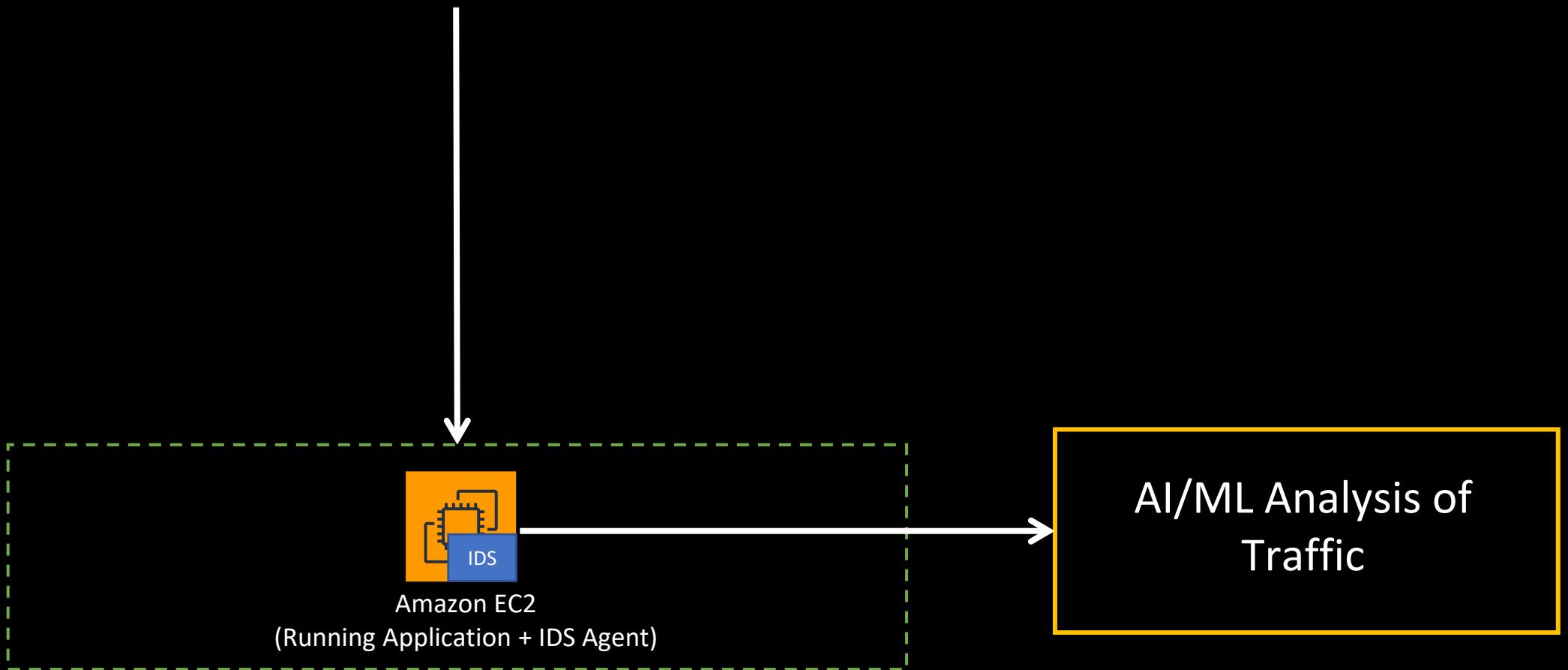


- Scans L3-L7 traffic
- Detects and sends alerts
- Prevents malicious traffic from reaching application

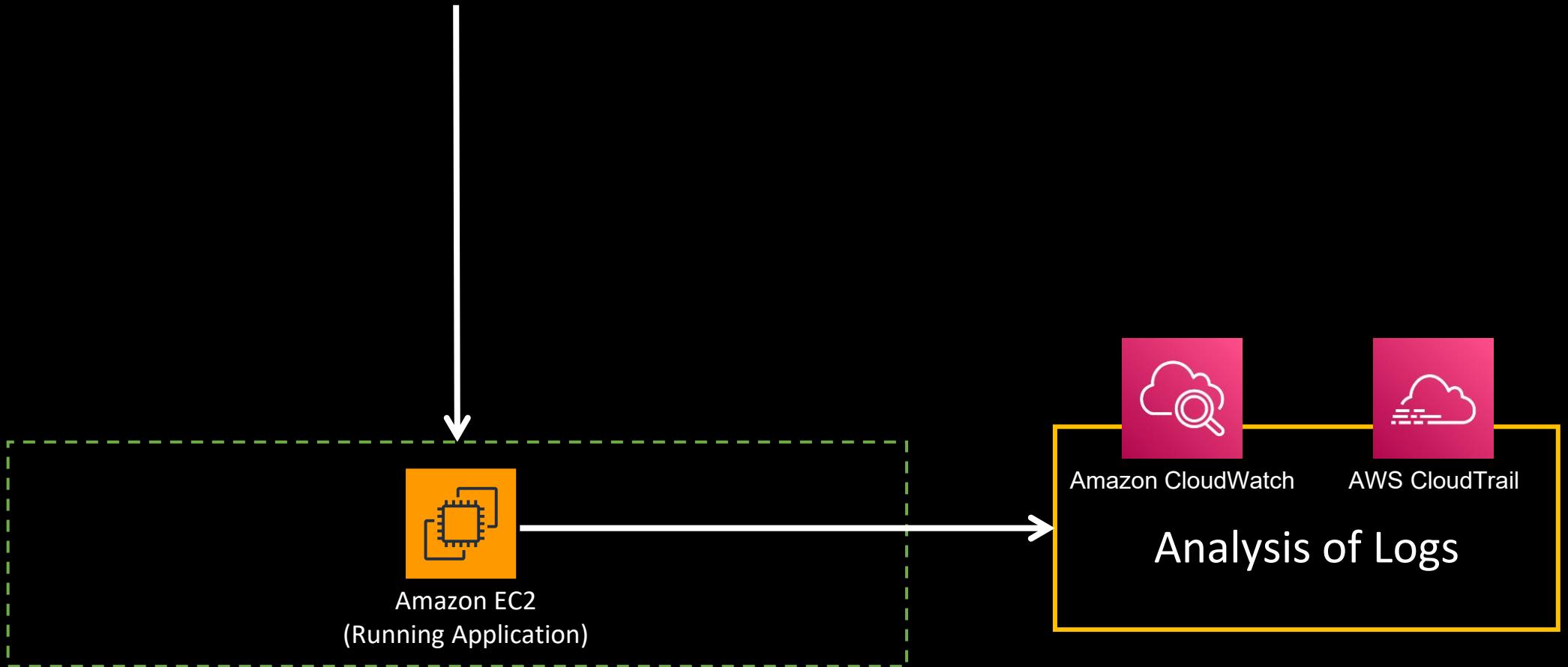
IDS



IDS



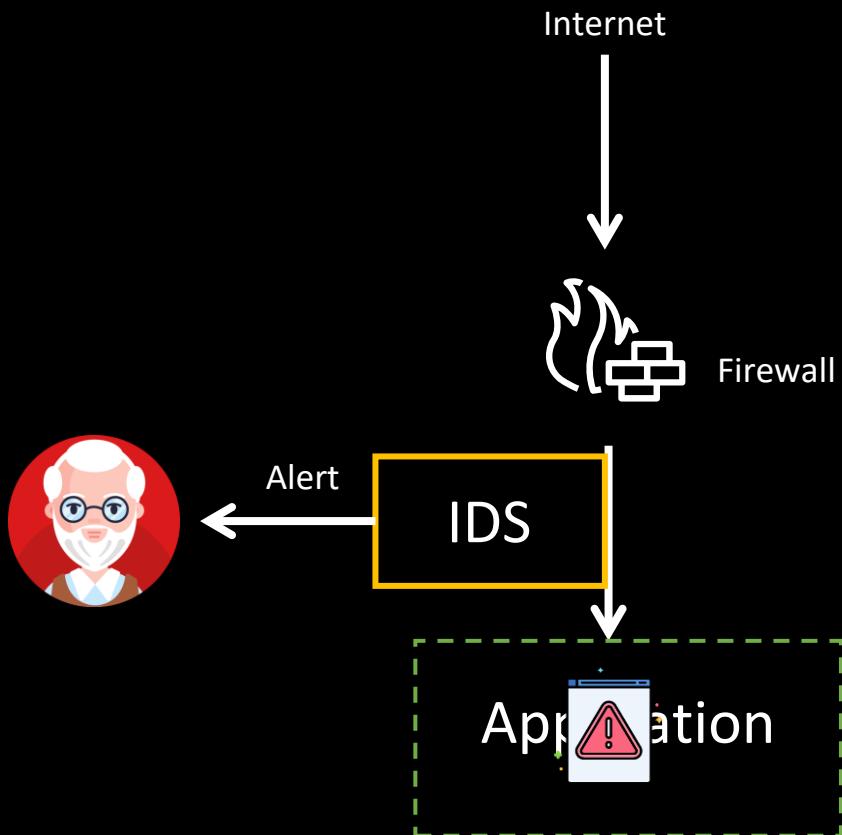
IDS



IDS

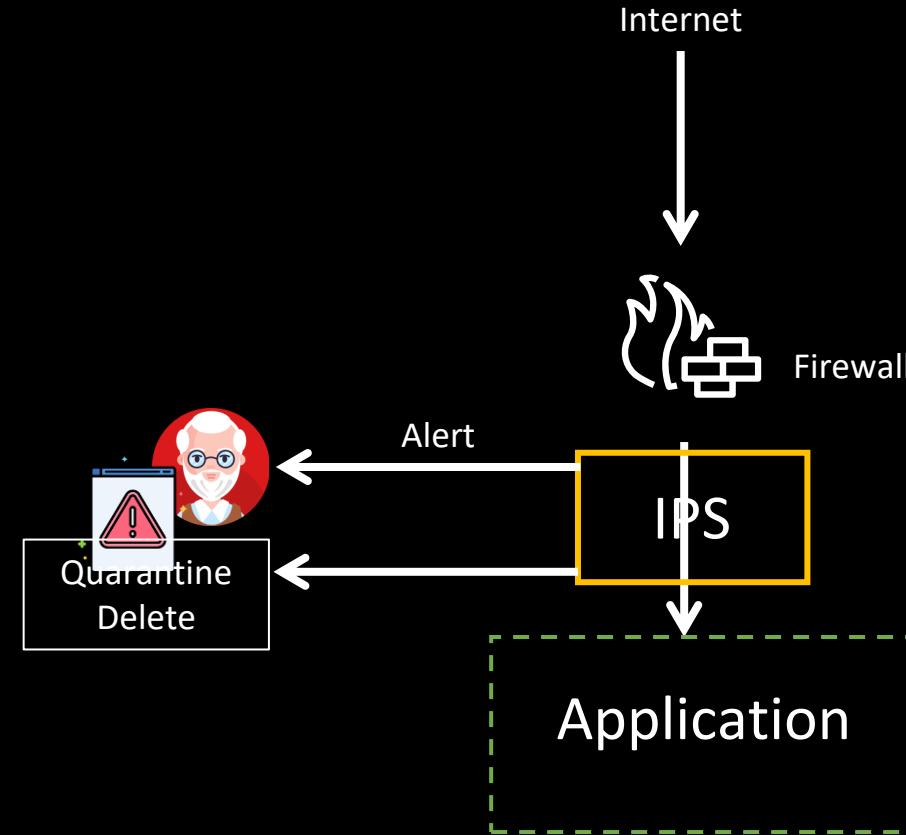


IDS



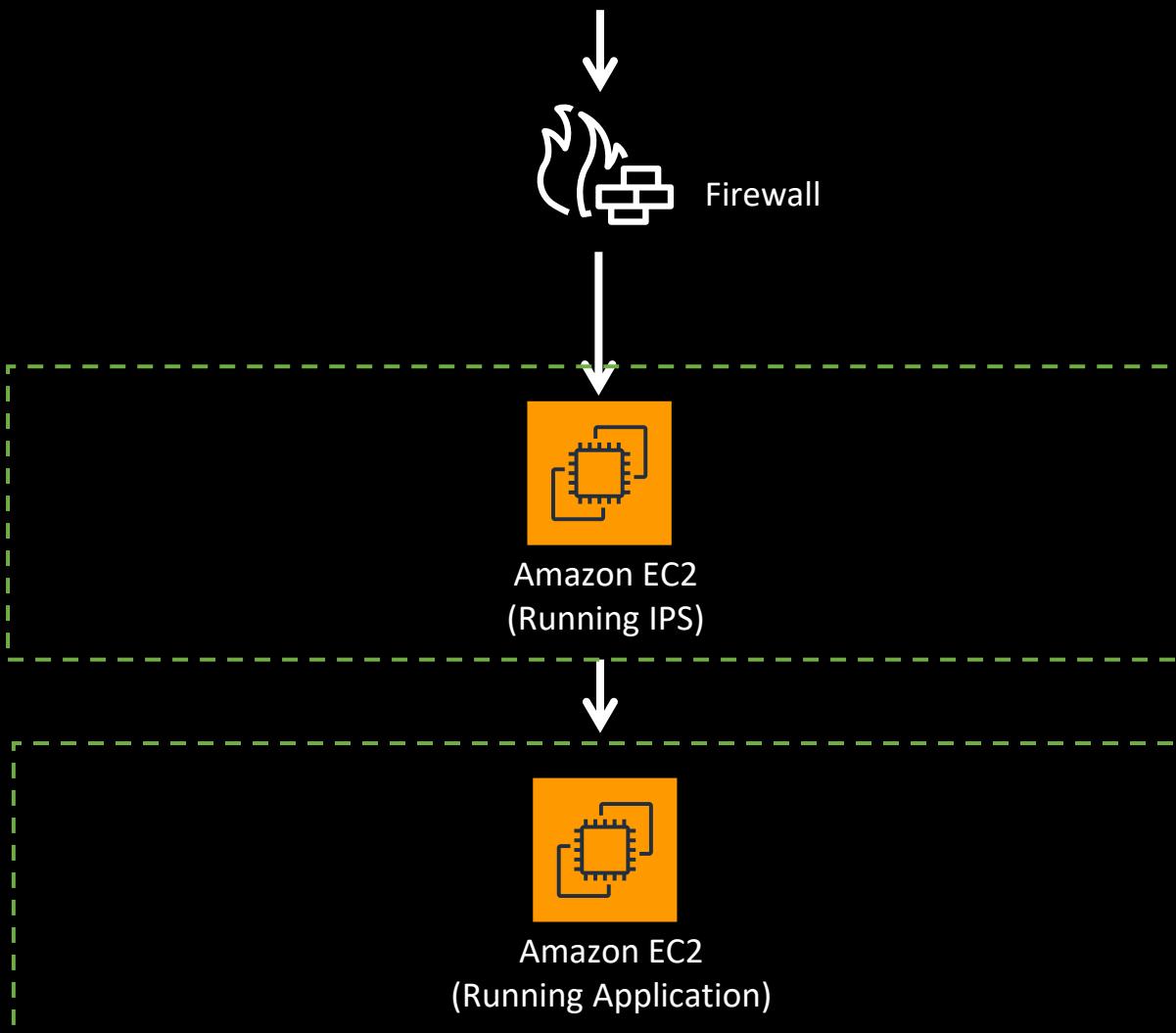
- Scans L3-L7 traffic
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IPS

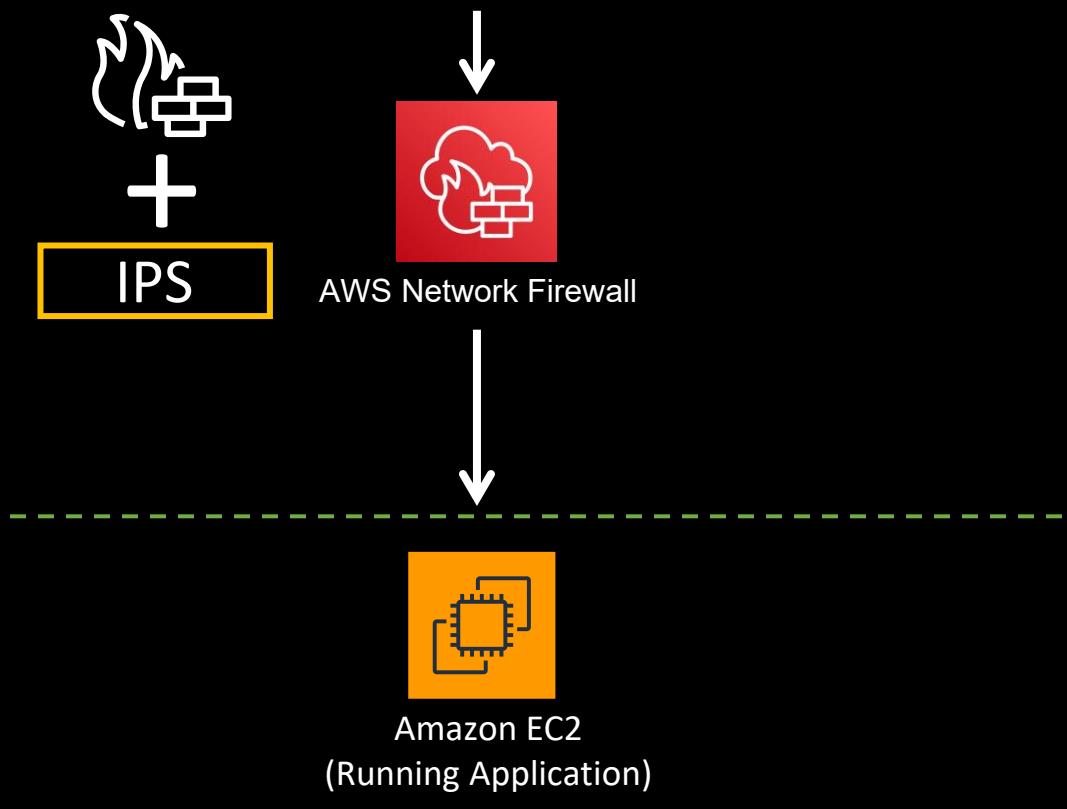


- Scans L3-L7 traffic
- Detects and sends alerts
- Prevents malicious traffic from reaching application

IPS



IPS



IDS/IPS Vs NACL/Security Group

- NACL/Security Group works on just L3/4 layer
 - IDS/IPS works on L3-L7
- Security group does NOT have deny rules
 - IPS have deny rules
- NACL/Security Group doesn't have "intelligence"
 - IDS/IPS has sophisticated rules that gets updated
- IDS/IPS can introduce latency to the app

SECTION 3 – SYSTEM DESIGN OF MODERN APPLICATIONS

Must Knows for System Design Interviews

- Microservices
 - Using Load Balancer Vs. API Gateway
 - Sync Vs. Async patterns
- Database Selection
 - SQL Vs. NoSQL
- Caching
 - Caching of Database and CDN
- Security
 - AuthN/Z, Encryption at Rest and Transit
- Make it Scalable and Highly Available

URL Shortener (TinyUrl/Bit.ly)

Bitly | Link Management

app.bitly.com/B18u37VkmAW/bitlinks/2UWIXp4

Apps New Tab 3080 Amazon ElastiCache... SAM local testing Database Migration... Whitepapers – Ama... Best practices for m... Map AWS services t... The Kubernetes API... Google Kubernetes... AWS Well-Architect... Lambda functions a... Map of the AWS W... How do I prepare f... AWS reInvent 2018... Other bookmarks Reading list

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11 TOTAL CLICKS

11 Email, SMS, Direct TOP REFERRER

8 United States TOP LOCATION

5 Results Clicks all time

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bit.ly/38FkUy1 1 click

SEP 2 Rocking AWS Serverless - A Real World Guide | Udemy
bit.ly/38vs6wV 1 click

SEP 2 Agent of Change - YouTube
bit.ly/2YkOKbb 1 click

AUG 30 LinkedIn profile
bit.ly/3jtTi5x 4 clicks

AUG 30 Rocking Kubernetes with Amazon EKS, Fargate, And DevOps | Udemy
bit.ly/2UWIXp4 4 clicks

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4 TOTAL CLICKS

AUG 29 SEP 1

MONDAY, AUG 30 Total Clicks 2

DATA IN UTC

REFERRERS LOCATIONS

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EDIT

UPGRADE

QR CODE

4 

TOTAL CLICKS

Basic Functionality - Saving



<https://www.udemy.com/course/rocking-kubernetes-with-amazon-eks-fargate-and-devops/?couponCode=AUG21BP1>



Goes to bit.ly
Short URL saved into a database



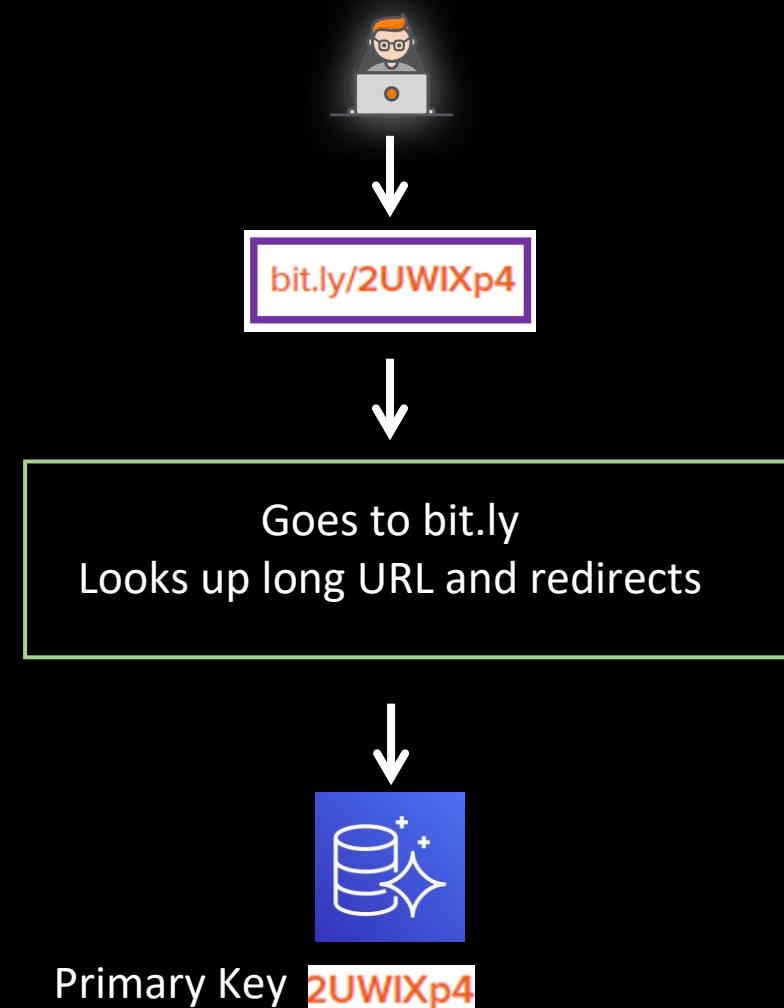
bit.ly/2UWIXp4

Primary Key **2UWIXp4**

Amazon Aurora

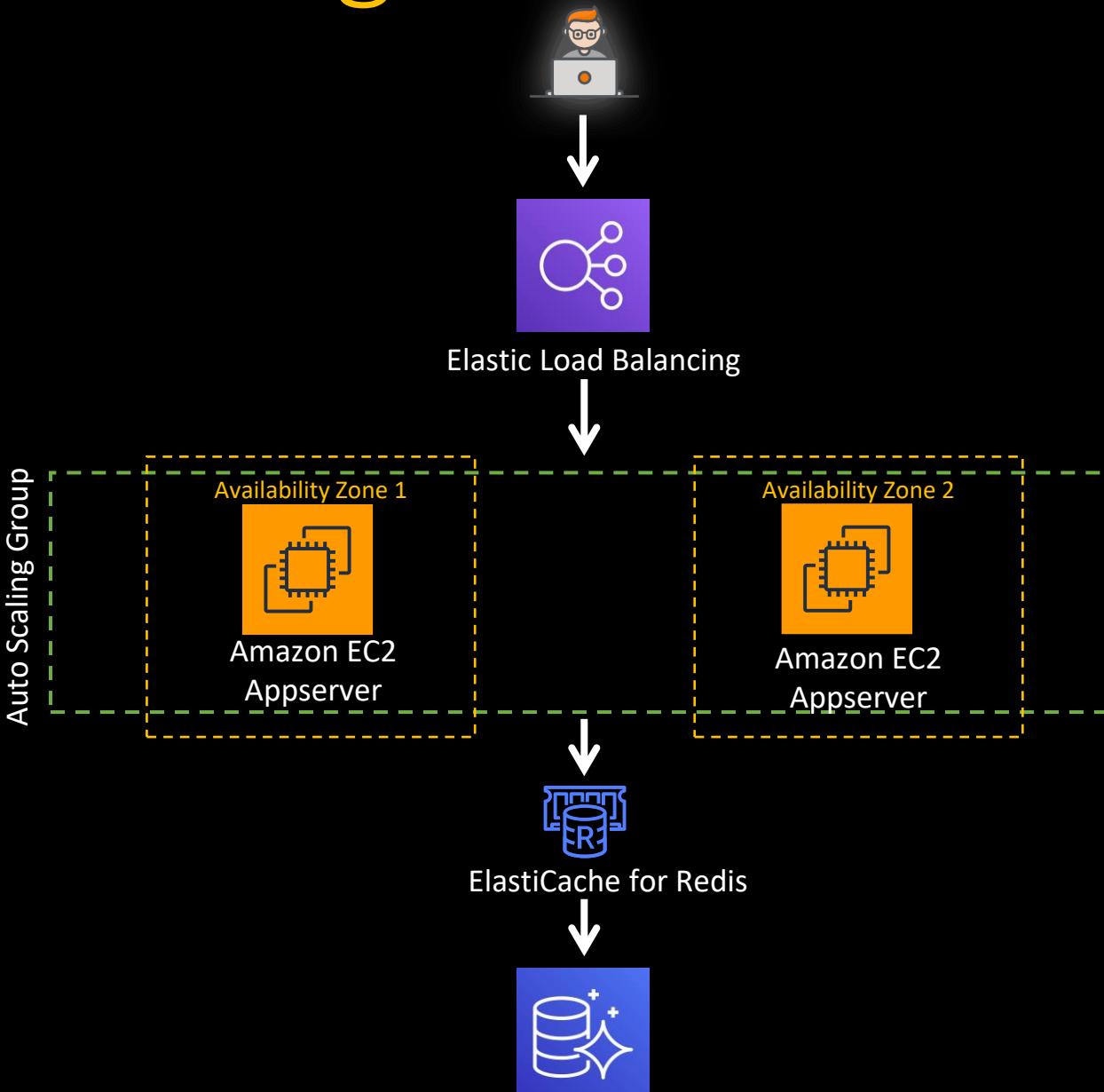
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Basic Functionality - Retrieving

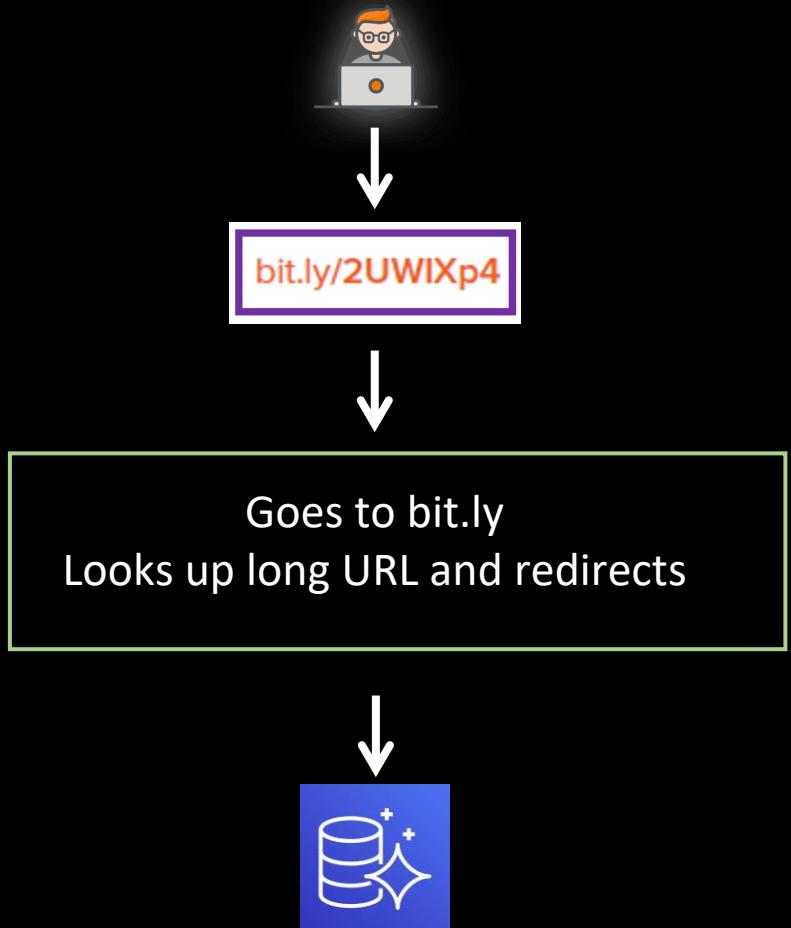


<https://www.udemy.com/course/rocking-kubernetes-with-amazon-eks-fargate-and-devops/?couponCode=AUG21BP1>

High Level Diagram



What is Interviewer Looking for?



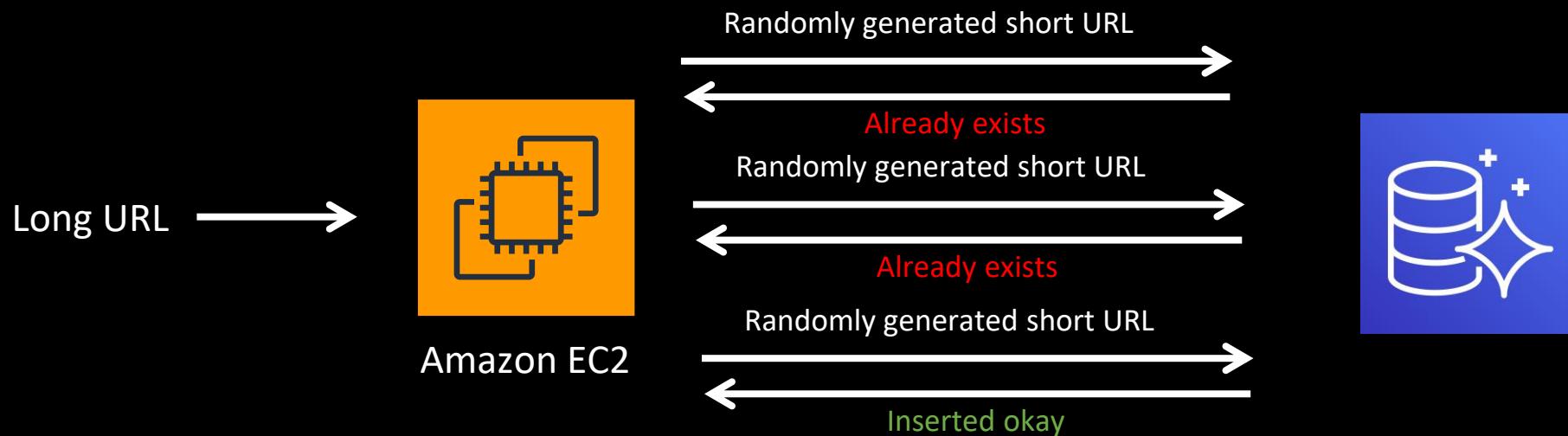
- How is the 7-byte shortened URL generated
- How can the URL generator scale?

Some Math!

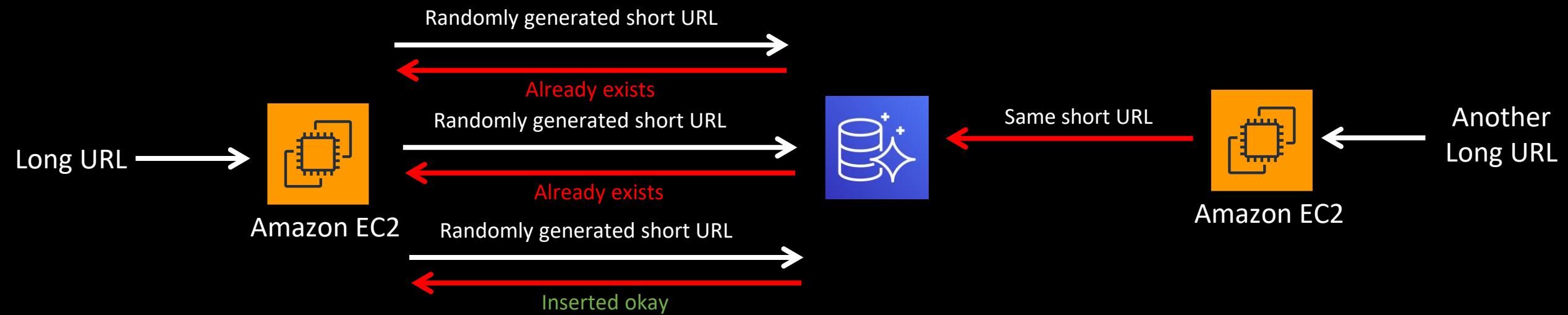


- Shortened URL can contain:
 - a-z = 26 characters
 - A – Z = 26 characters
 - 0-9 = 10 characters
- Total of $(26 + 26 + 10) = 62$ characters
- 7 characters URL out of 62 characters = 62^7
 - = 3.5 Trillion unique combinations = 42 bits (2^{42})
- Depending on rate of consumption, increase the shortened URL size

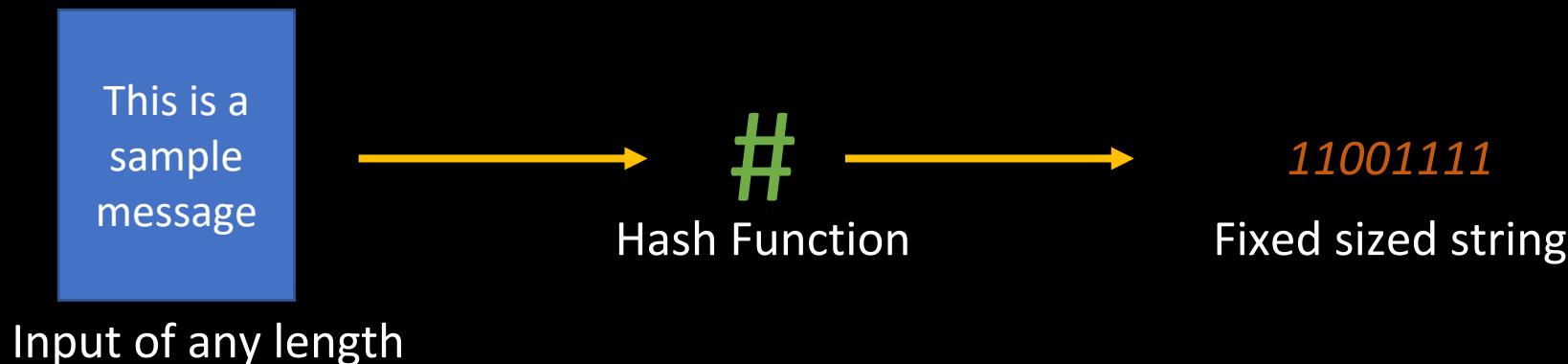
Bad Randomizer Approach



Bad Randomizer Approach



Taking Randomness Out – MD5



- Message Digest Algorithm 5
- Produces 128-bit value from an arbitrary length string
- Hash algorithm
 - Same input strings will always generate same output string
 - Two different strings can NOT produce the same output

MD5 Continued

- Take first 42 bits of the 128 bit MD5 output
- 42 bits to 7 characters
1101.... (Total 42 bits)
 $=2^1+2^1+2^0+2^1 + \dots$
 $=12345$

Base62

From Wikipedia, the free encyclopedia

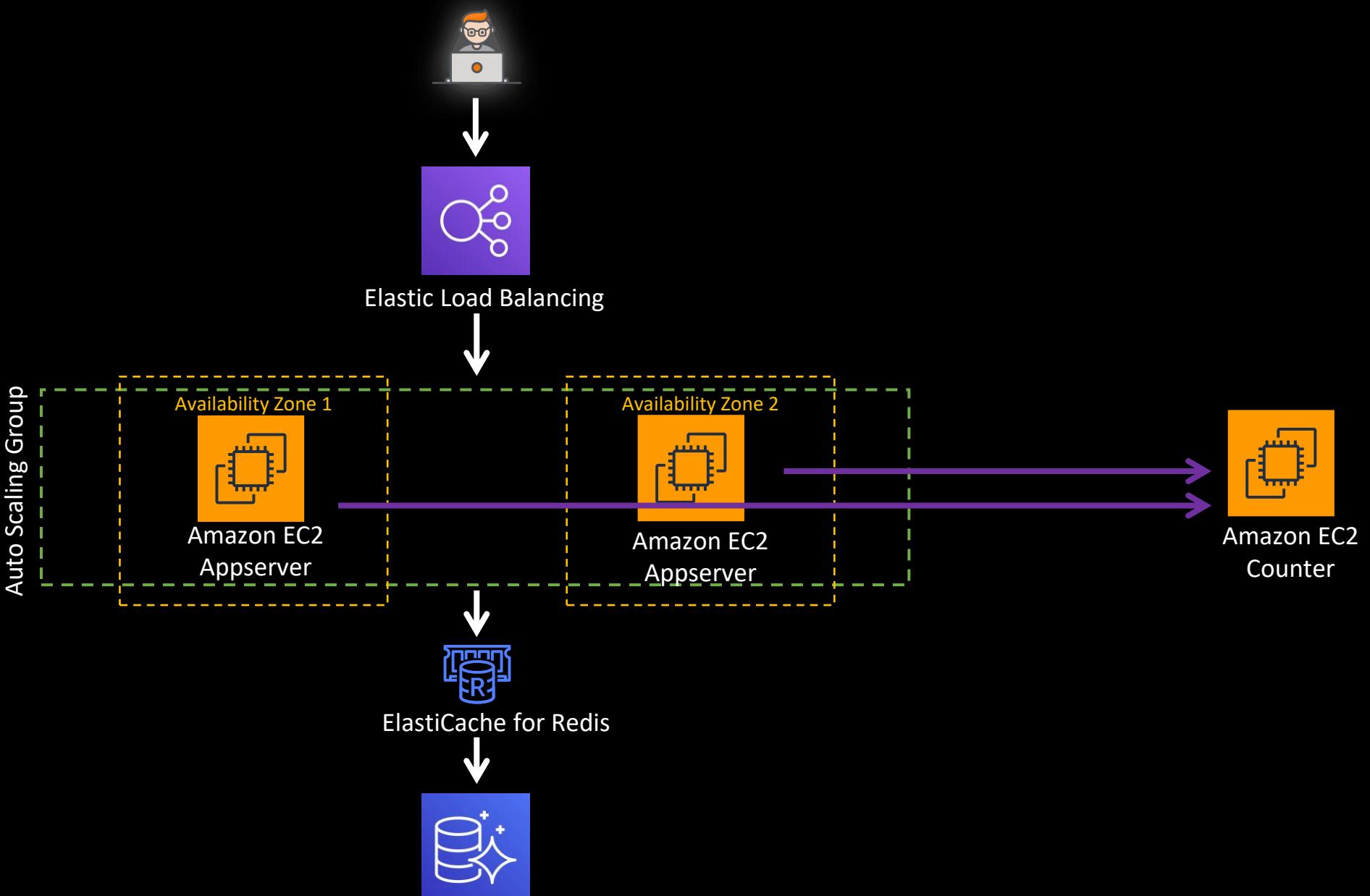
The **base62** encoding scheme uses 62 characters. The characters consist of the capital letters A-Z, the lower case letters a-z and the numbers 0–9. It is a [binary-to-text encoding](#) schemes that represent [binary data](#) in an [ASCII](#) string format.^{[1][2]}

Convert to Base 62 (Get numbers from 0-61)
=3idarWH

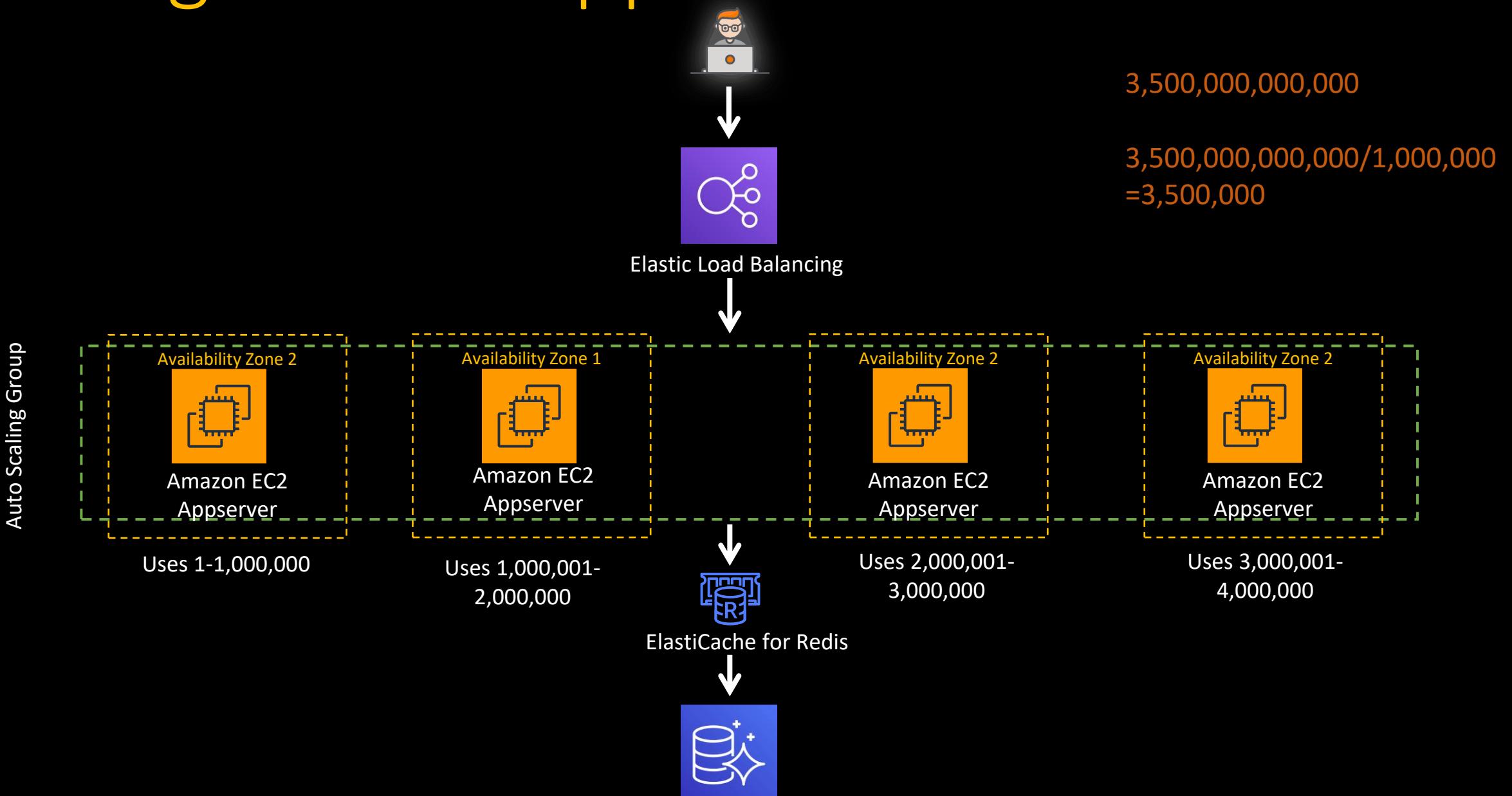
Ideal Approach

- 42 bits to 7 characters (Remember 42 bits translate to max 3.5 trillion in actual numeric)
- For each URL shortening request if the application has a unique number between 1 - 3.5 Trillion as input, the output will be unique
- For each URL request use a number, then increment it by one for the next request
- Do this from 1 - 3.5 trillion

Where should the Counter be?

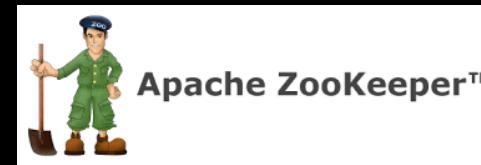


Range Based Approach



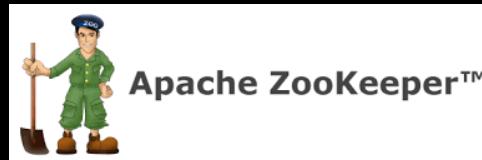
Assigning Ranges

Maintains ranges from
0-3.5 trillion with each
range of 1 million



Quick Detour to Apache ZooKeeper

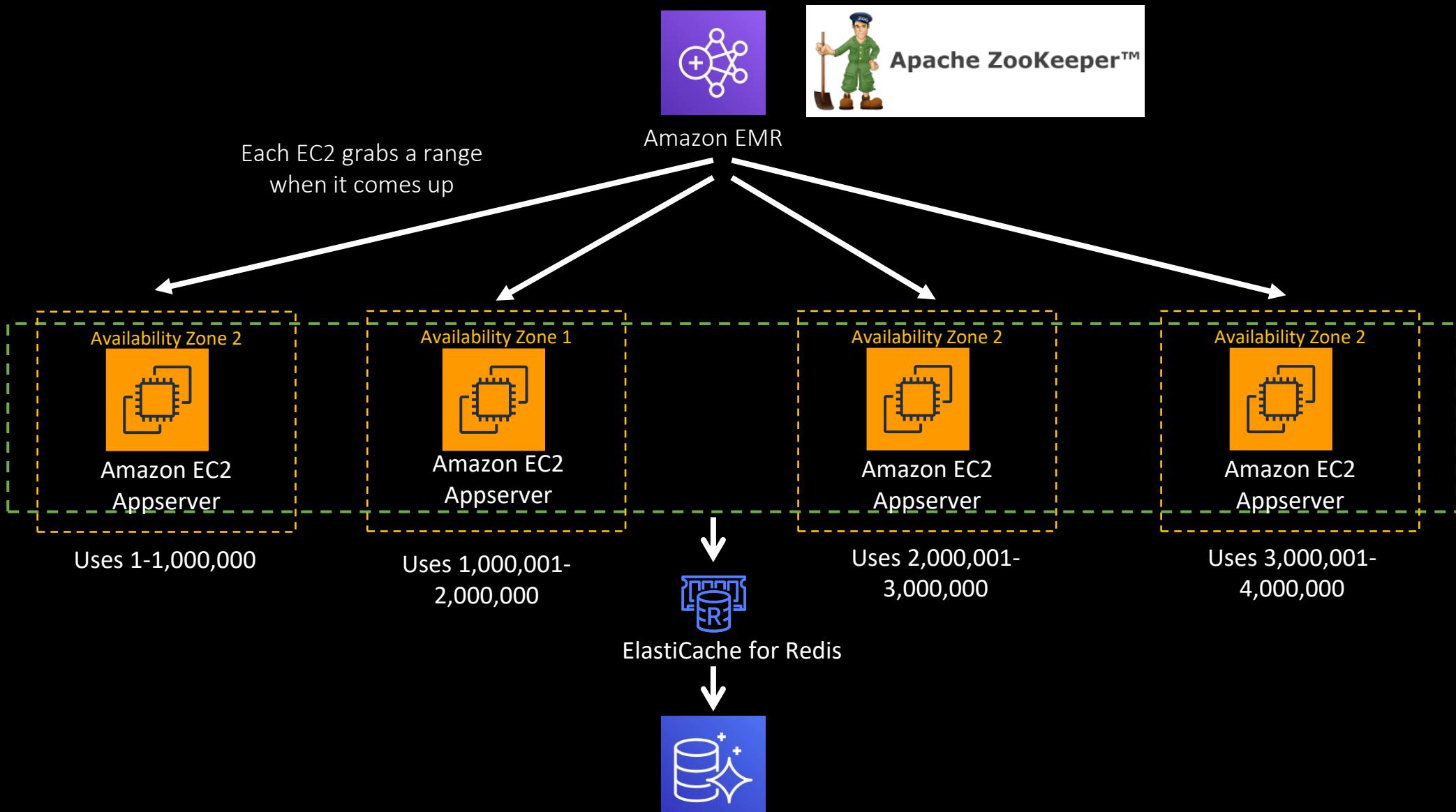
Maintains ranges from
0-3.5 trillion with each
range of 1 million



- Centralized service for maintaining configuration information
- Highly available and provides distributed synchronization
 - Better than running a counter service on single EC2
- Can be run in Amazon EMR

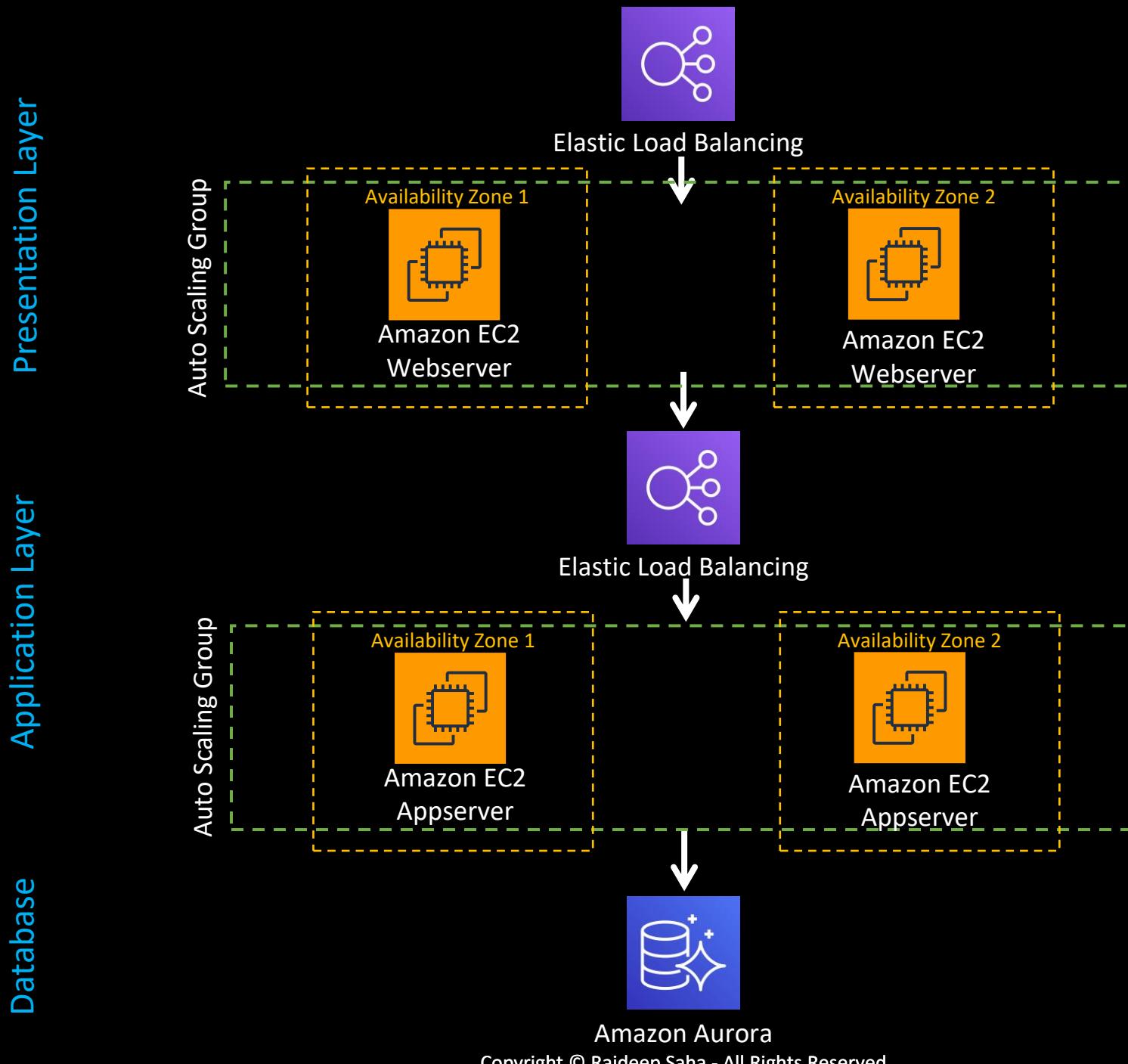
Assigning Ranges

Maintains ranges from 0-3.5 trillion with each range of 1 million



Amazon/Flipcart

Three-Tier Architecture



Requirements/Design Spec

REQUIREMENTS

- Product catalog
- Shopping cart
- Buy product
- Product recommendation

DESIGN SPEC

- Scalable
- Highly Available
- Cost efficient
- Secure

Three-Tier Architecture

EC2 Vs Kubernetes Vs Serverless

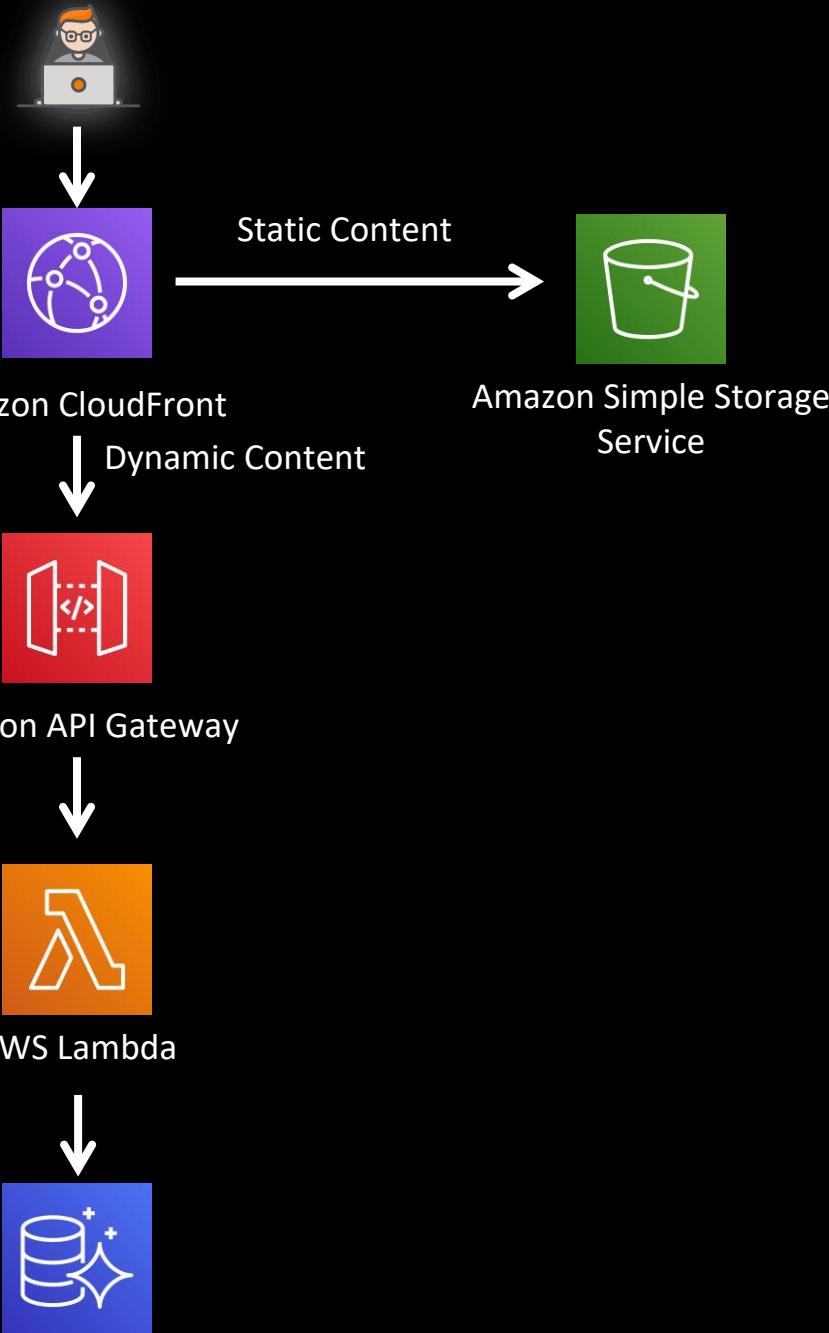
Presentation Layer

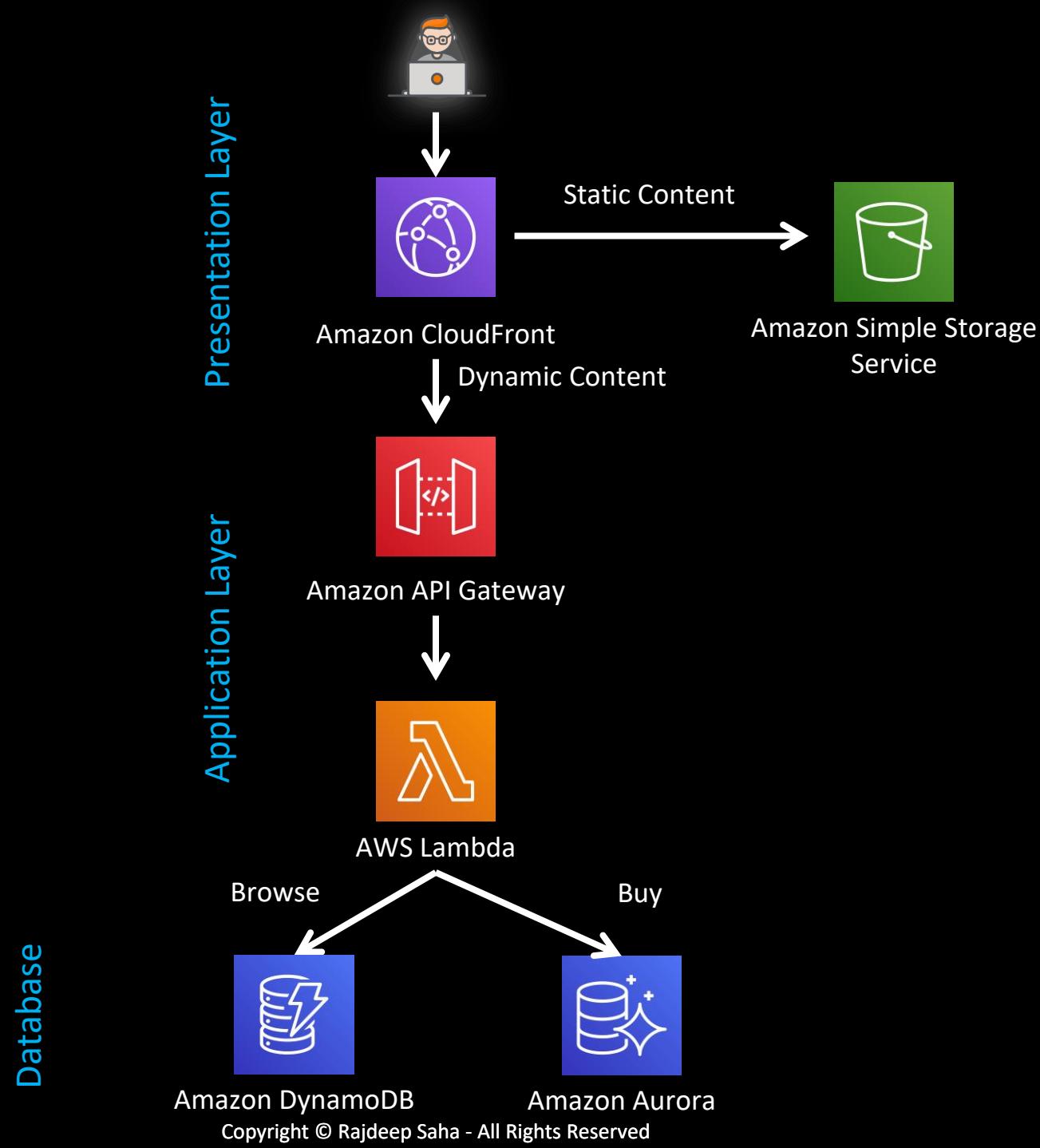
Application Layer

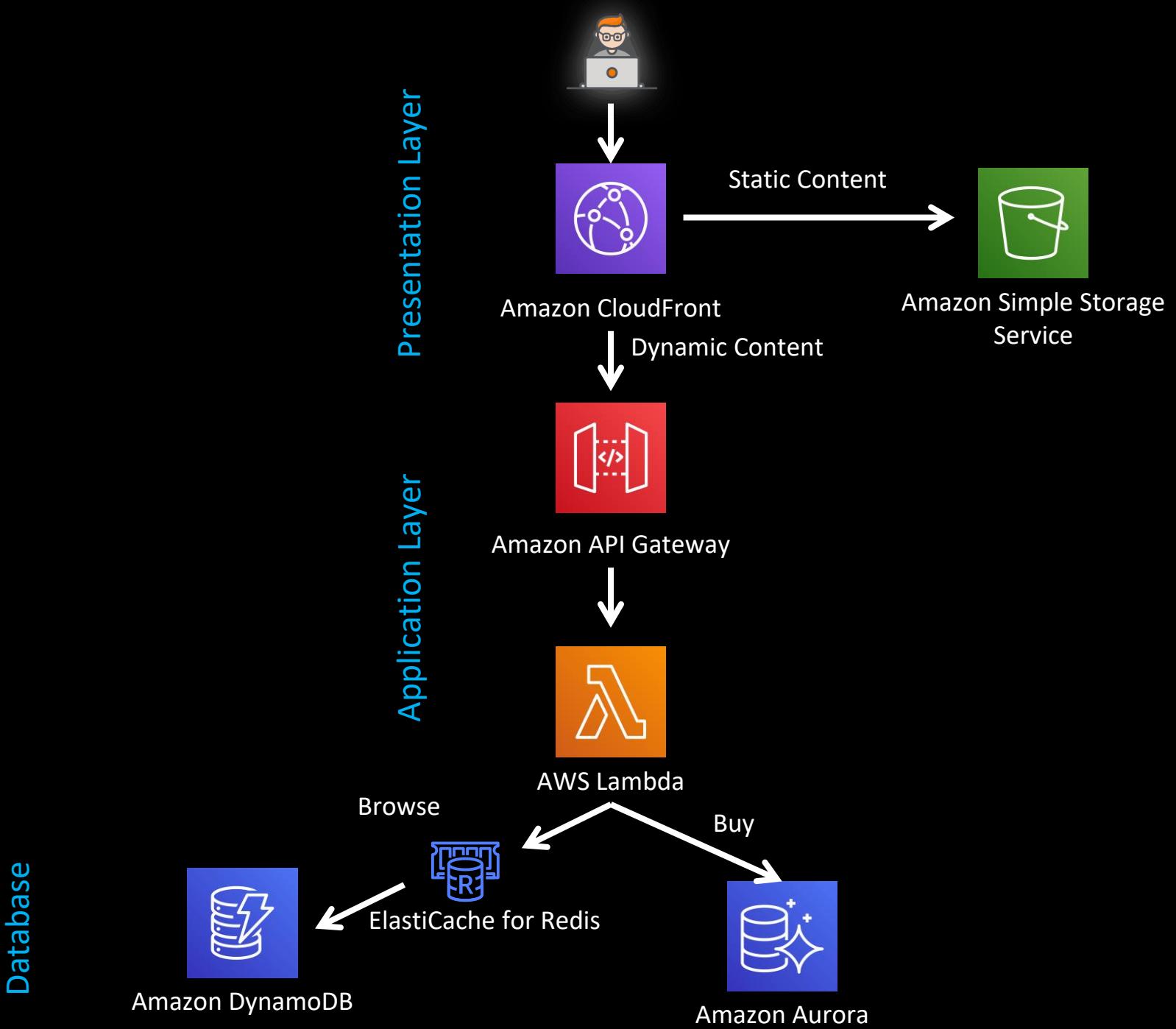
Database

Amazon Aurora

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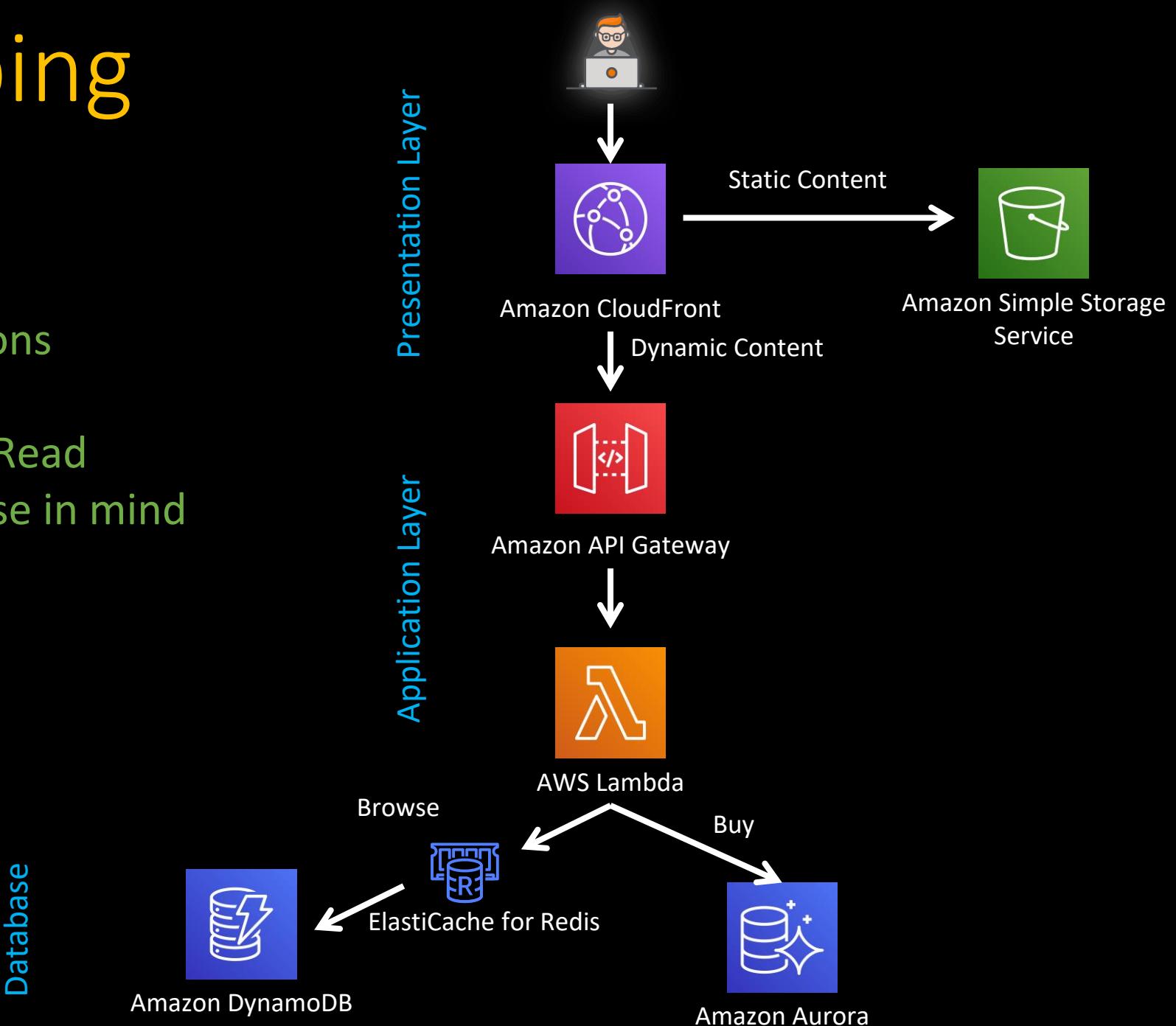






Database Probing

- Expect lots of database questions
- Keep SQL vs NoSQL, sharding, Read replica, caching, global database in mind



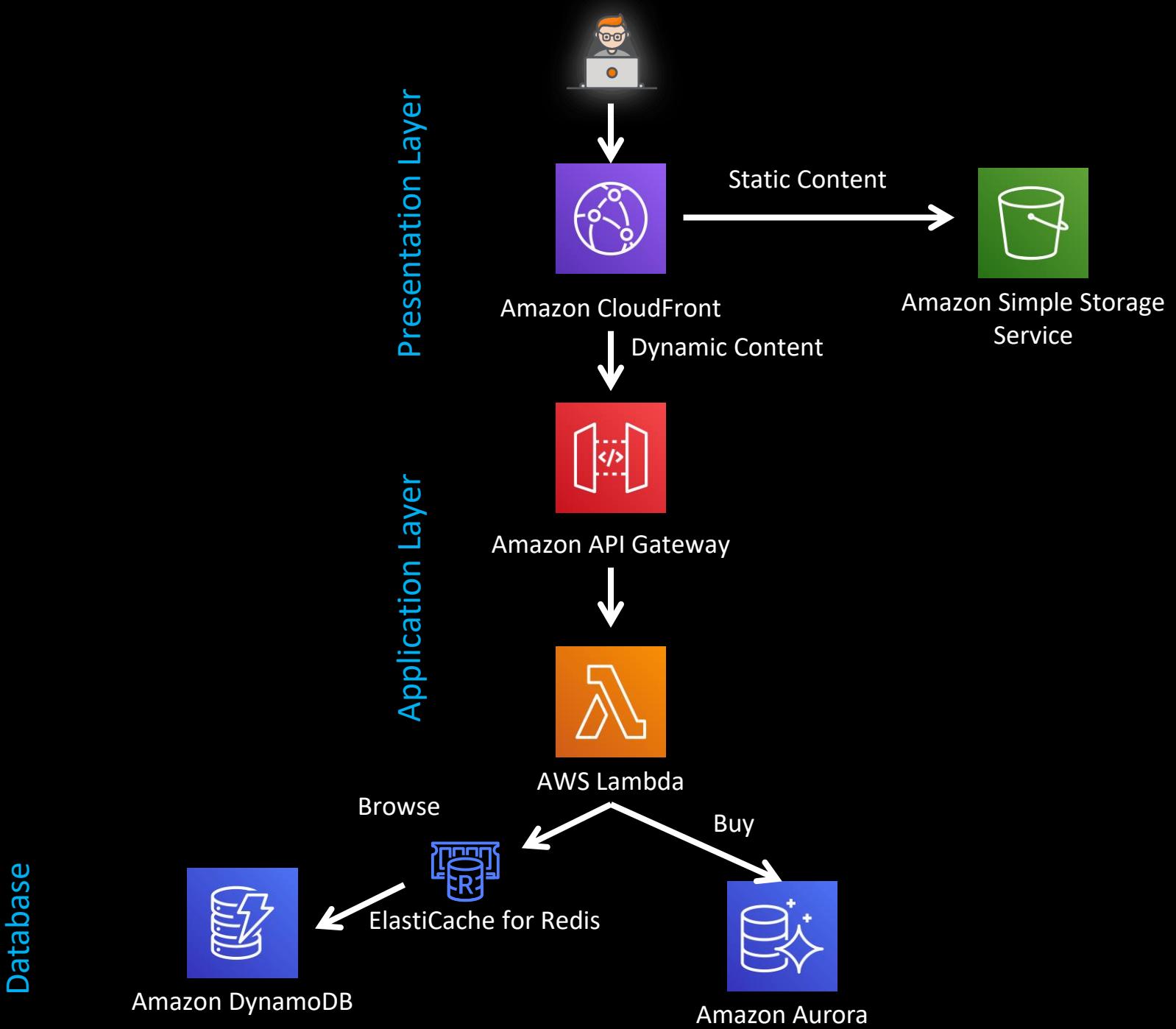
Shopping Cart

Product

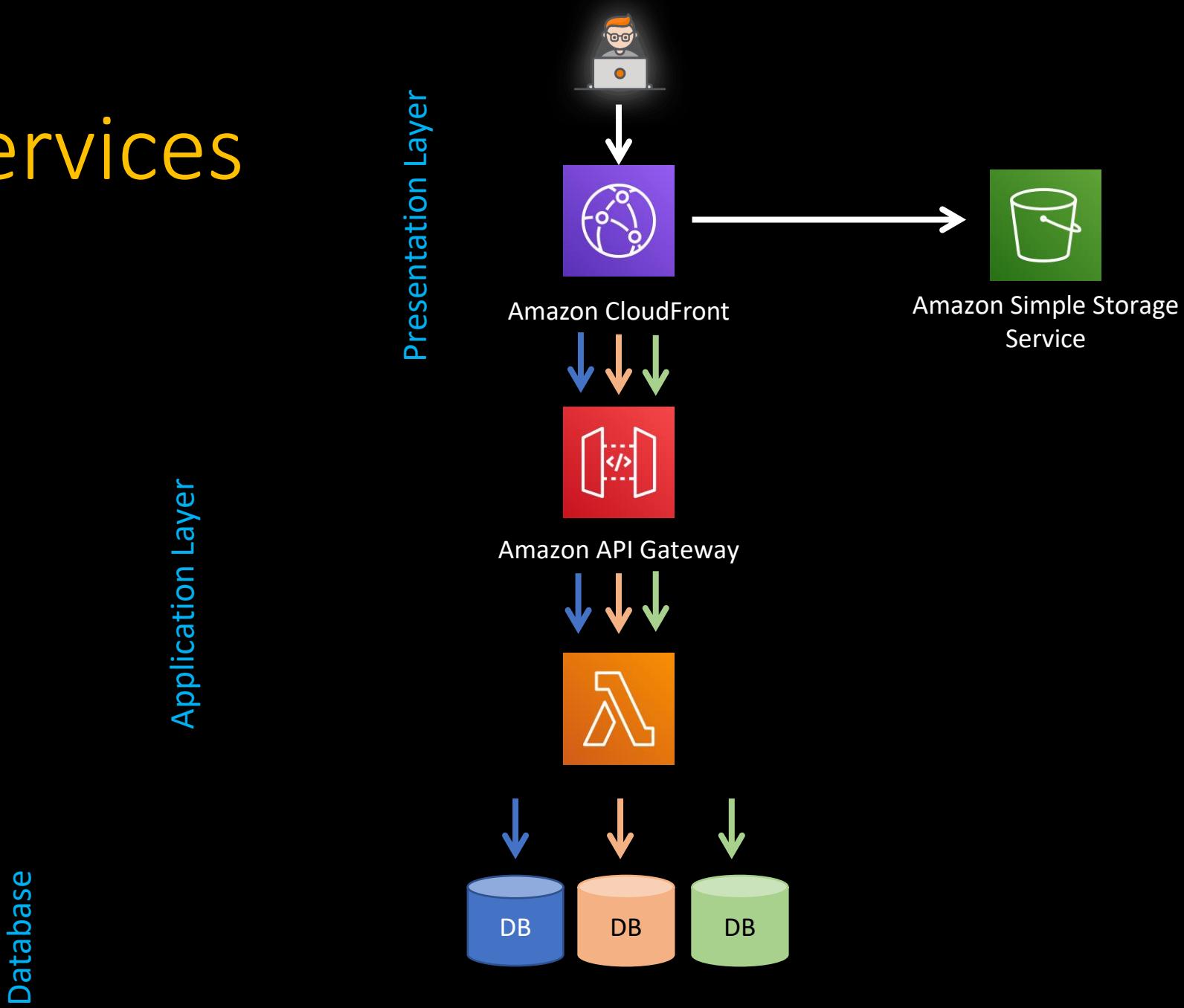
| ProductID | Name | Price | AvailableCount |
|-----------|----------------|-------|----------------|
| 100 | TV | \$450 | 5 |
| 200 | Face Mask | \$5 | 1000 |
| 300 | Hand Sanitizer | \$10 | 0 |

ShoppingCart

| CartID | PersonLogin | ProductID |
|--------|-------------|-----------|
| 10000 | John.Wilson | 100 |
| 10000 | John.Wilson | 200 |
| 20000 | Tina.Smith | 300 |

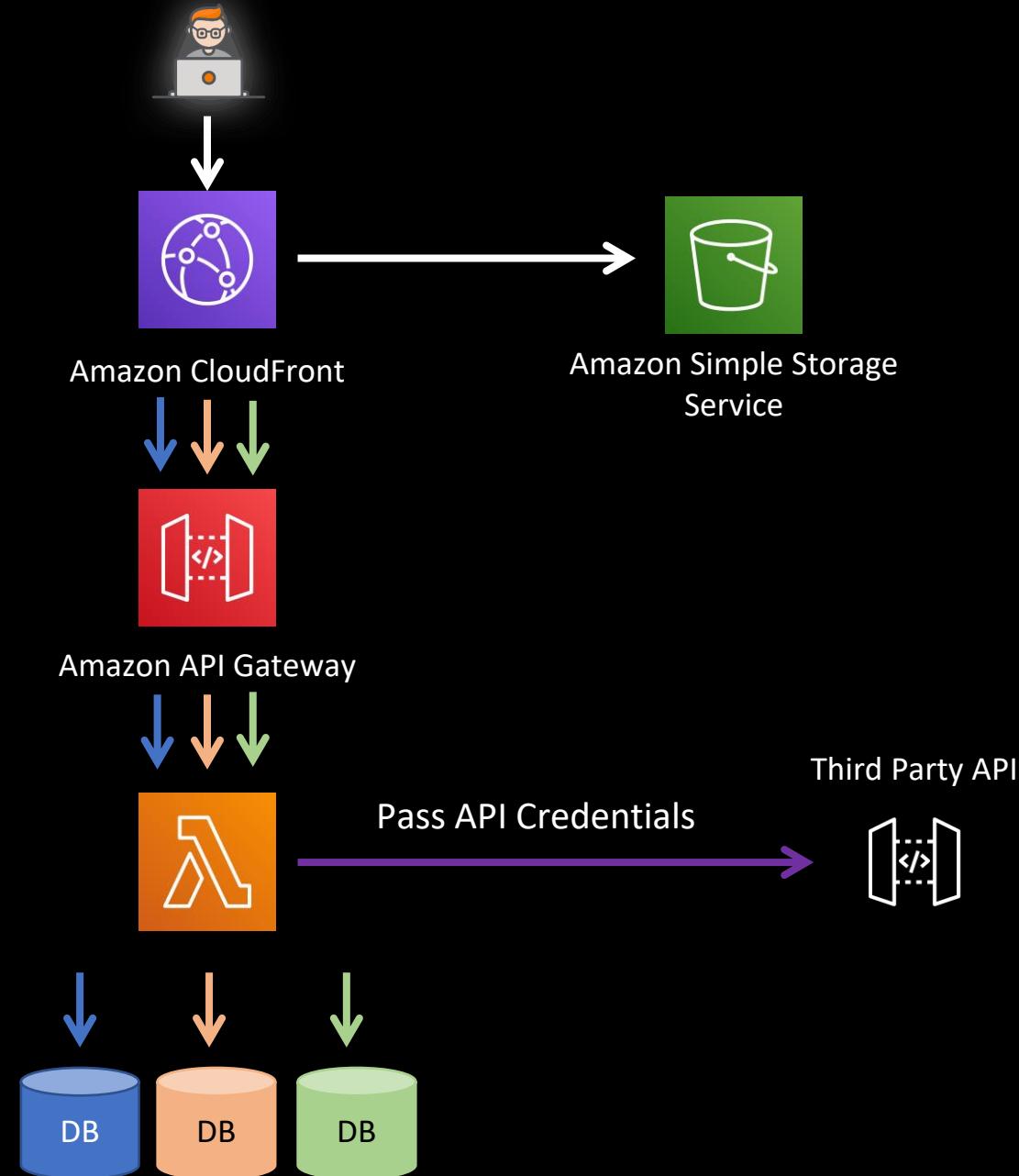


Several Microservices

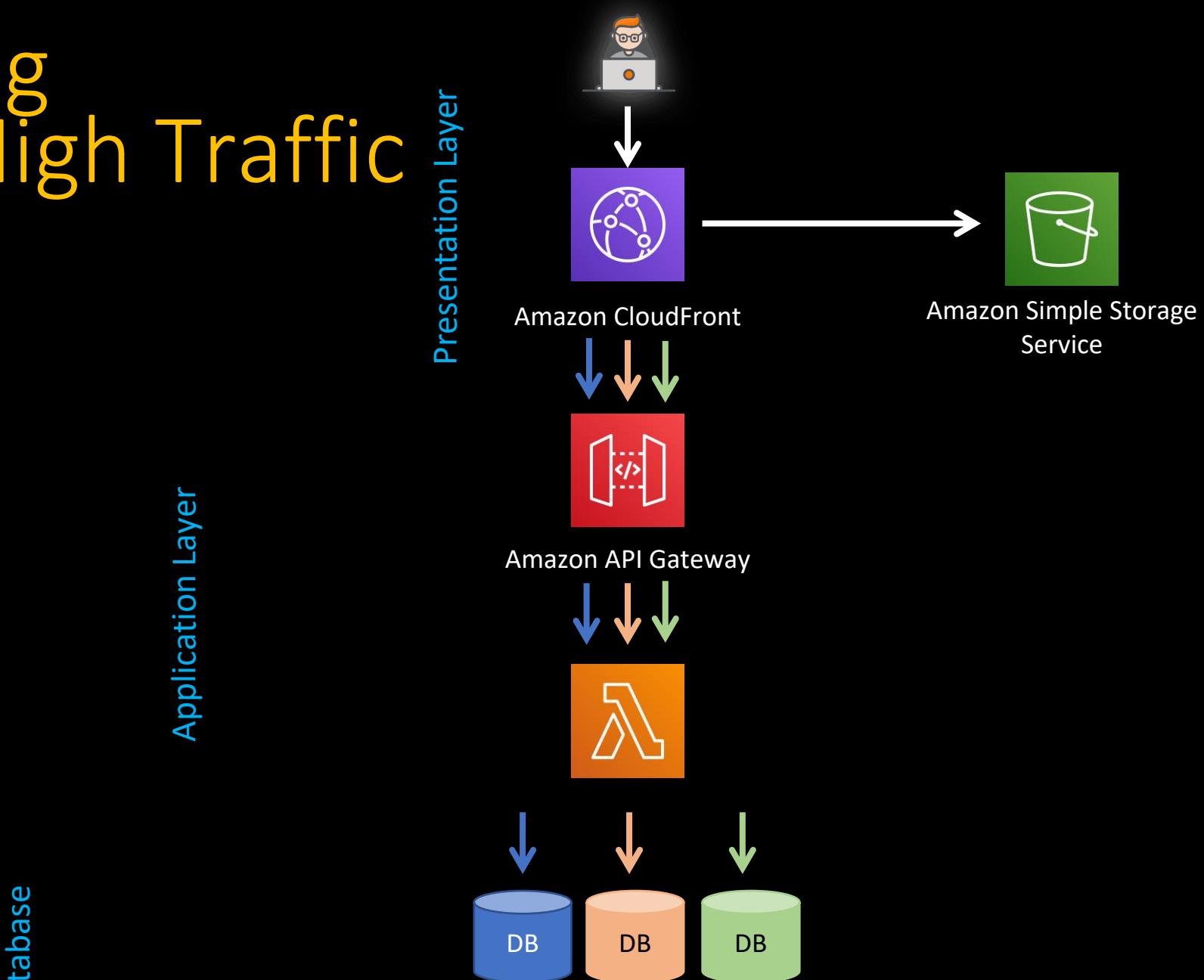


Calling Third Party APIs

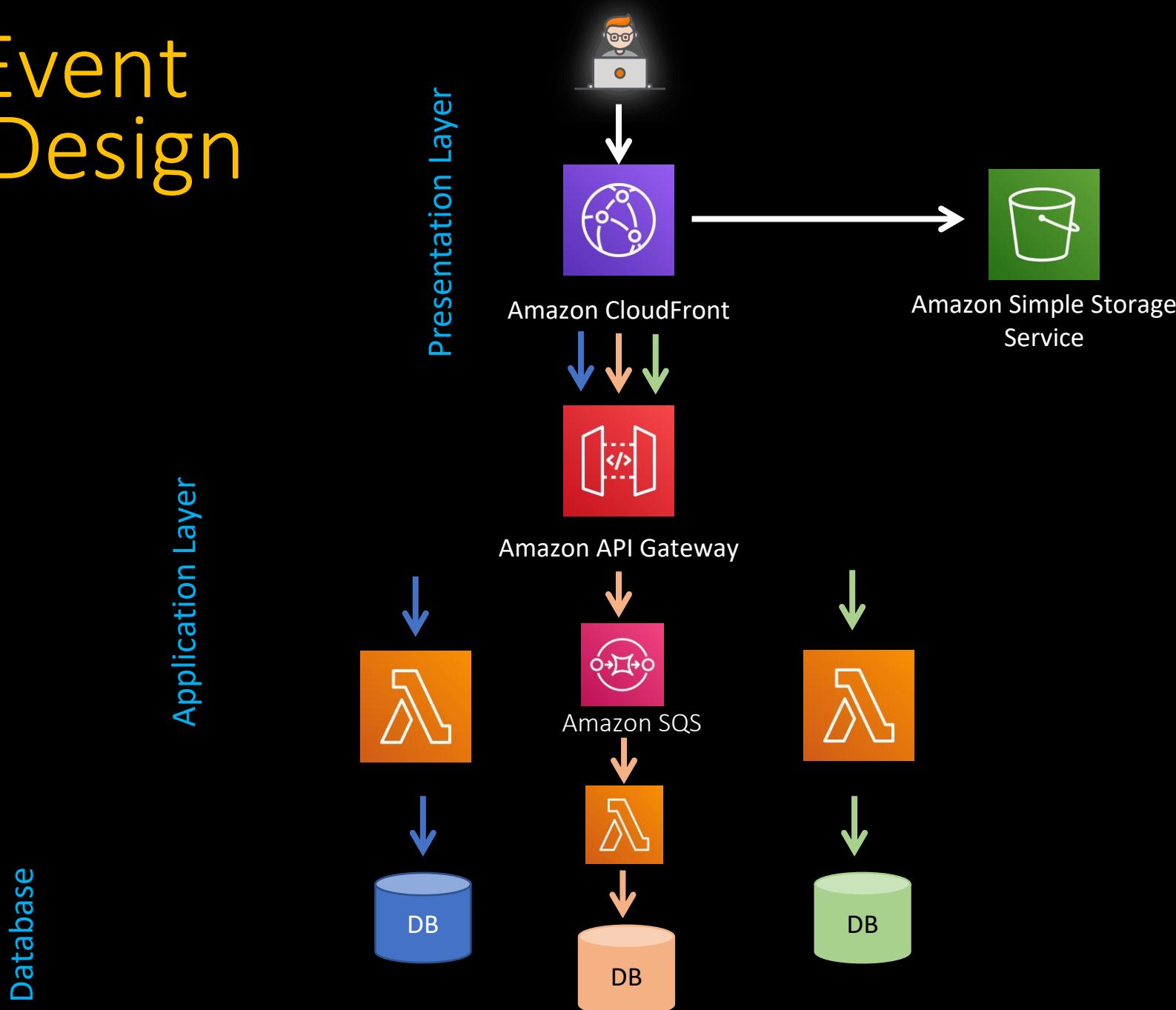
Database
Application Layer
Presentation Layer



Handling Super High Traffic



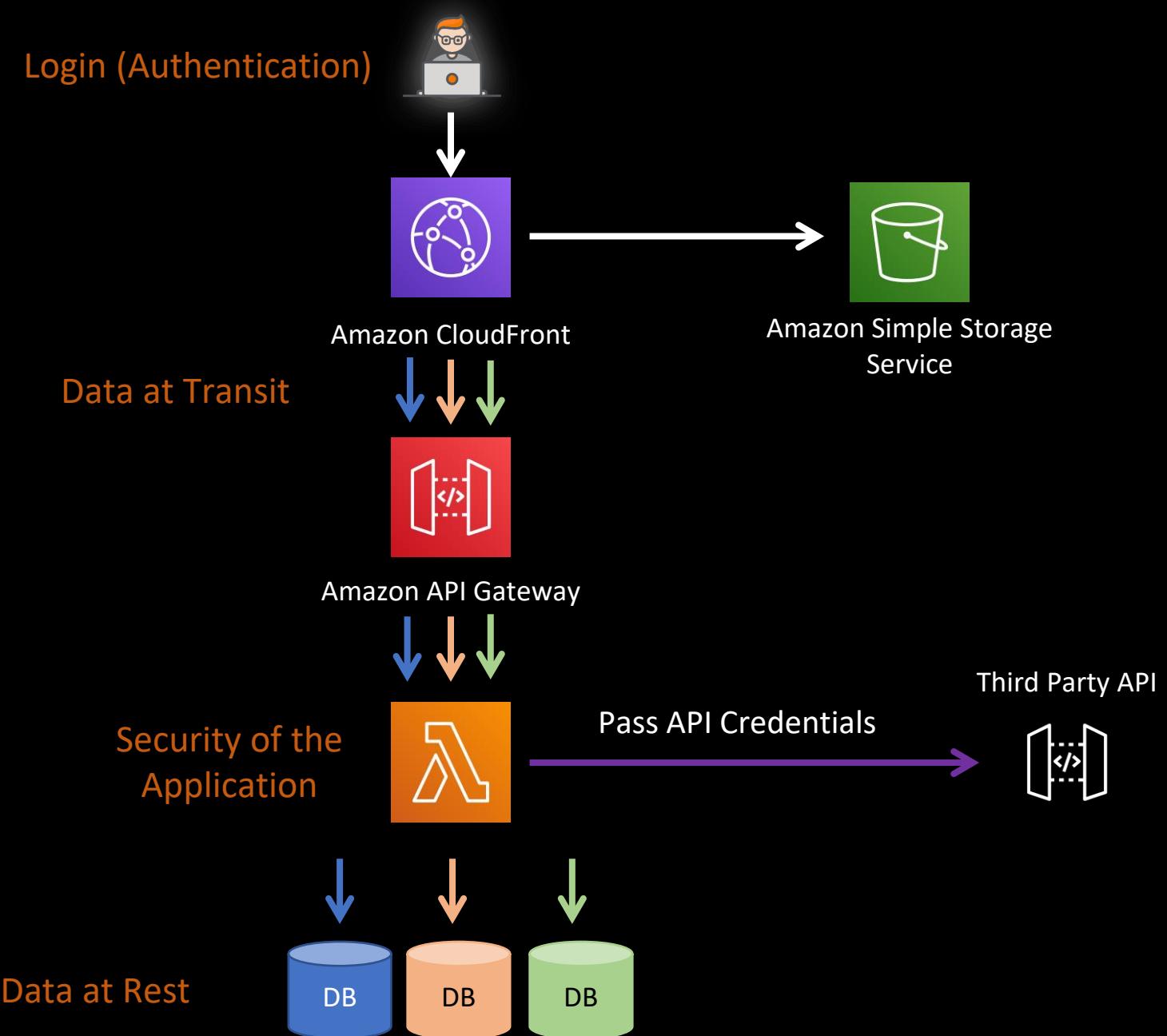
Async/Event Driven Design



Product Recommendation

- Collaborative Filtering
- Check Tinder system design recommendation part

Security





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