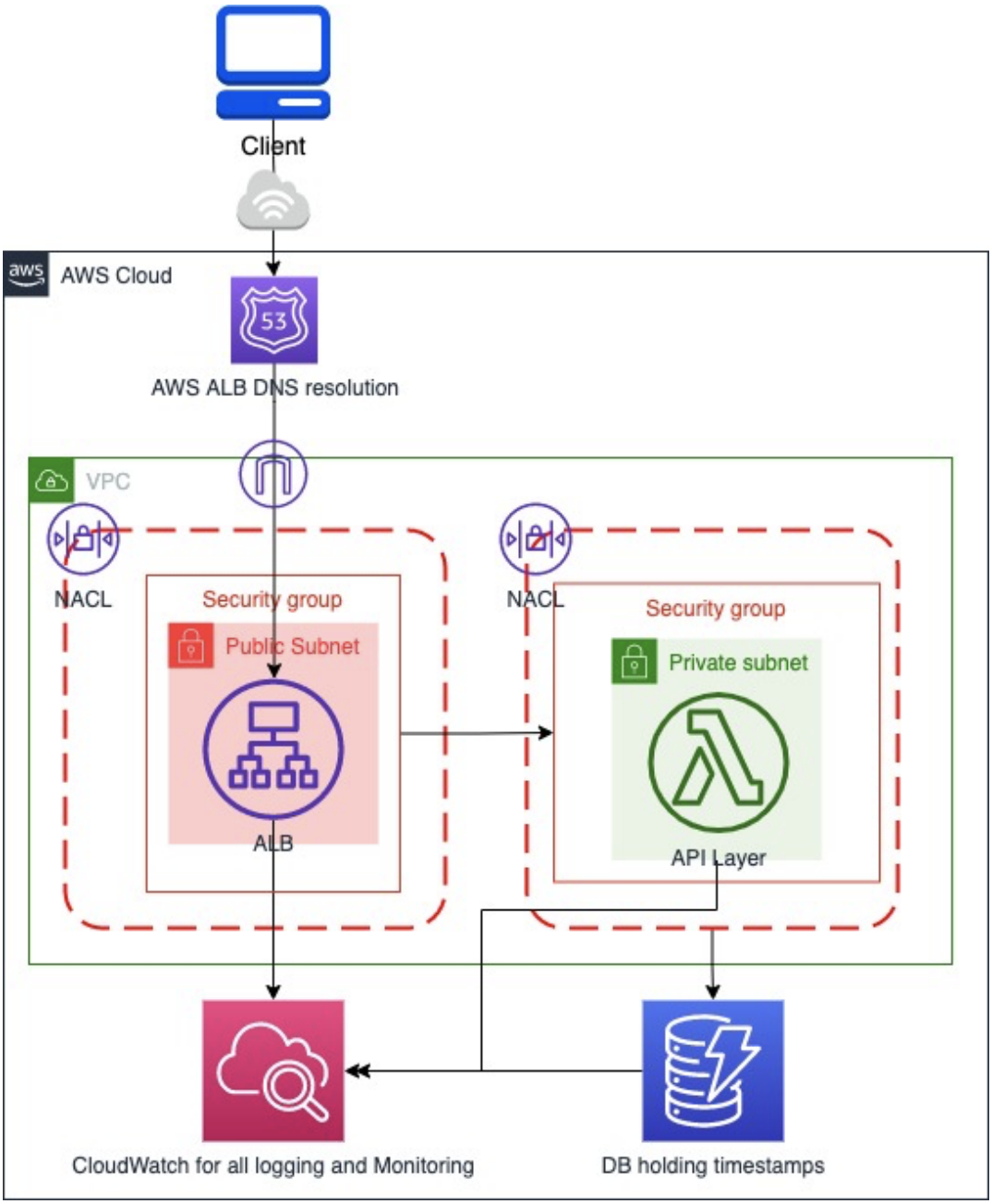
System Engineering Assignment

Requirement: write timestamp to DB when POST methods is issued to /app endpoint

Index:

Code base: https://github.com/asrivastava-github/writeDBAPI

High-Level design (As illustrated and explained below)



The solution consists of two major components:

1. API layer which is being served by AWS Application Load Balancer with AWS Lambda as it's target.
2. DB layer which is being served by AWS DynamoDB

When a client (Terminal, Browser etc) sends the request to API using AWS ALB external DNS or Public IP:

- The internet facing AWS Application Load Balancer receives it and based on the endpoint (path - /app in this case) passes it on to the respective target.
- Lambda is connected to target groups of ALB ready to serve the requests.
- Based on request Lambda executes the business logic (writing timestamp to DB in this case) and sends the response back to ALB which forwards it further to client.

Low-level design

An attempt to explain each component/function in detail covering below points

- Network
- Security
    - IAM
    - Network Security
        - Network Access Control Lists
        - Security Group
        - VPC endpoint
        - TLS
    - User Authentication
- API Layer
- DB Layer
- Logging and Monitoring

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1. Request goes to the internet looking for Address or IP mention.

2. ISP eventually finds where the requested DNS or IP needs to land, in this case Amazon Web Service, where Route 53 is ready to receive it.

3. Route53 routes the request to the Internet gateway (IGW) of VPC where solution (ALB + Lambda) has been deployed.

4. Now if connectivity and routing has been properly sorted, the request will be received by ALB as ALB sits in a Public Subnet which has routing enabled for internet → Internet gateway and local → Public Subnet. Public Subnet is attached to a NACL which allows traffic from the internet on HTTP and HTTPS port. It allows outbound traffic on

ephemeral ports as well **(Required for ALB to respond back).** Another layer of security on ALB, it's own security group allowing traffic only on HTTP and HTTPS ports.

5. ALB will analyse the request and based on the endpoint (path) mentioned in the request it will route it further to one of it's Target, which is nothing but Lambda. Lambda resides inside a Private subnet which has NACL allowing internal/local traffic on port 80 and 443, **along with Amazon's DynamoDB Service IP list for eu-west-*region on ephemeral ports required for DynamoDB to connect with Lambda which is deployed inside VPC.**

6. Lambda is a serverless compute ready to execute the code/business logic based on the request sent to it in the form of an Event. Lambda also carries its own security group rules to accept HTTP and HTTPS traffic from ALB security group only.

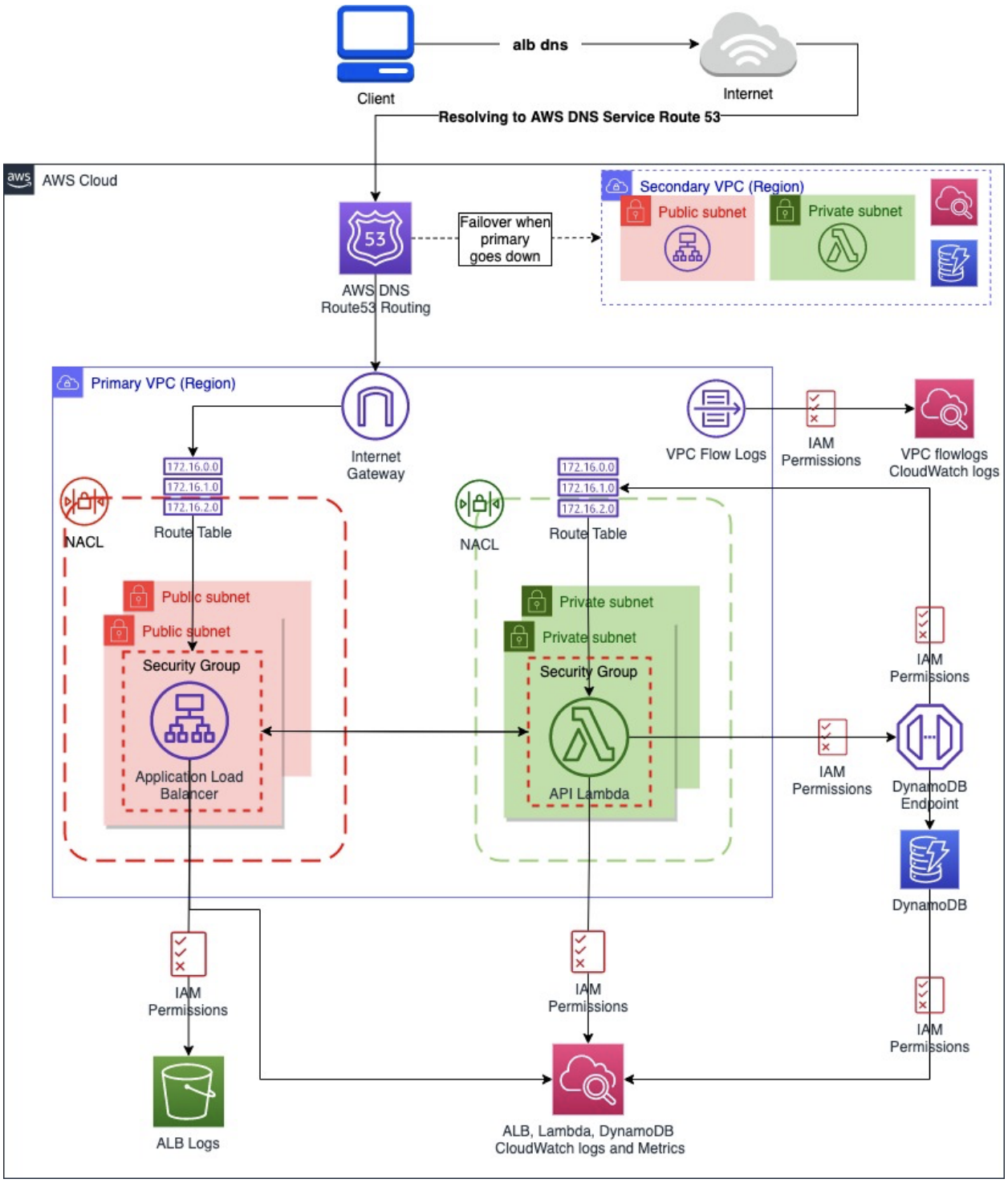
7. Post understanding the request, Lambda sends the response back to ALB in a specific format which ALB can understand and serve it further to the client, again if connectivity is properly sorted for outbound as well.
    a. Now it's worth explaining how the actual requirement is being served here. When Lambda receives the request where the **endpoint** (Path) is **"/app"** and the method is **POST**, it tries to connect to DB layer which is being served by AWS DynamoDB.
    b. Since Lambda is deployed under my/customer's VPC (NOT AWS own VPC), it cannot connect to AWS Managed Service DynamoDB straight away. Lambda will need a VPC endpoint created for DynamoDB which AWS facilitates free of cost but making it work is tricky, so ultimately a Secured Serverless compute has a way to connect to Serverless DynamoDB securely and internally (within AWS network, without going to internet)
    c. Post executing the business logic lambda responds to ALB and ALB takes care further.

8. HTTPS connectivity can be enabled by creating a certificate based on DNS and attaching it to the ALB HTTPS listener. This has not been covered here.

9. Additionally Lambda can easily be integrated with Cognito (AWS managed user authentication Server or IDP needs to be explored, Same is the case with DynamoDB).

10. Logging and Monitoring has been enabled at each level.
    a. Stating with vpc flow logs to capture all the request entering to VPC
    b. ALB logs being stored to s3 and AWS provided metrics
    c. Cloudwatch logs have been enabled for Lambda.
    d. Cloudwatch metric for DynamoDB

Below is the low level design touching each component.



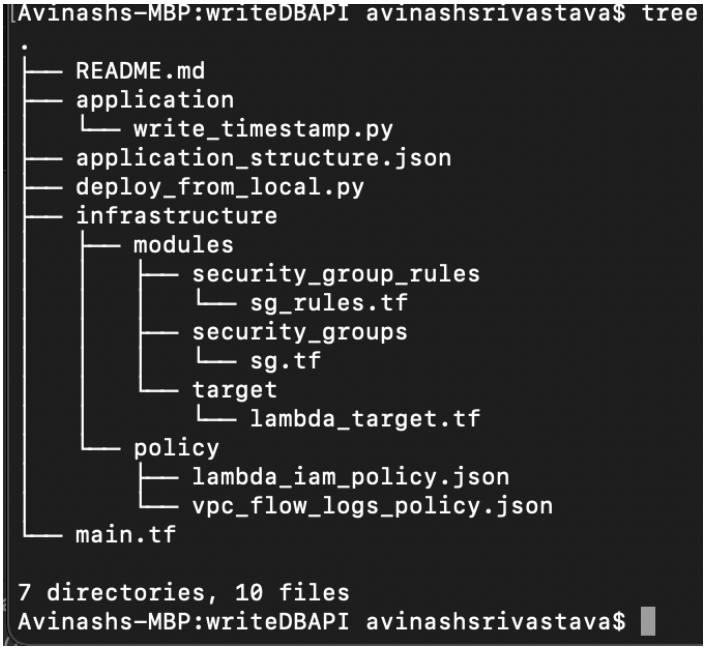
Deployment

Checkout below README for in depth detail

https://github.com/asrivastava-github/writeDBAPI/blob/main/README.md

- ## Directory Structure

    - Deployer file --> deploy_from_local.py
    - Business logic/API layer/Application -> ./application/write_timestamp.py
    - An attempt to design the application structure so that deployment can be controlled via config file --> application_structure.json
    - Infrastructure builder --> main.tf
        - Create security group rules
            --> ./infrastructure/modules/security_group_rules/sg_rules.tf
        - Create Security groups
            --> ./infrastructure/modules/security_groups/sg.tf
        - Configure the infrastructure of API layer e.g. Lambda and target groups etc.
            --> ./infrastructure/modules/target/lambda_target.tf



- Prerequisite:
    - Terraform version v0.13 or above must be installed. This project is build/tested using v0.14.2/0.15.4
    - Python version 3 (3.5 above) should be installed, This project is build/tested using Python 3.8.2
        - python3 -m pip install boto3 (pip Install boto3)
        - python3 -m pip install requests (pip Install requests)

    Avoiding file clutter else a requirements.txt will also be okay to define the required python packages. [Quickstart — Boto 3 Docs 1.9.42 documentation]

- AWS Configure
    - Create an Admin account on AWS which has access to provision the resources like ALB, Lambda, DynamoDB, CloudWatch, IAM etc
    - Install AWS CLI on your machine, Make sure you are able to connect to AWS post configuring AWS with "aws configure"
    - Default region used is eu-west-1

- Worth checking: Login to AWS console --> go to VPC --> Managed prefix lists, It should exist for s3 and dynamoDB or for either of them. If not, don't worry terraform wil created.

- Clone Project repository writeDBAPI

  git clone https://github.com/asrivastava-github/writeDBAPI.git

- Deployment: plan --> apply --> visual test --> planDestroy --> destroy

  cd writeDBAPI

  Currently I am owning **avi-assignment-api-service** bucket so if you are testing/deploying the solution, and getting bucket exists error, let me know I will delete, Alternatively you can change the bucket name in application_structure.json as s3 bucket names are unique.

- Run below to plan the system infrastructure

  - python3 deploy_from_local.py -a plan -e poc

- Run below to provision the system infrastructure

  - python3 deploy_from_local.py -a apply -e poc

- Starting visual testing/Using the system

  1. You can hit http://<ALB DNS printed as output> in the browser to see the welcome page.

  2. Run the below curl command which will create the timestamp entry inside dynamoDB

curl -X POST http://<ALB DNS printed as output>/app

3. Hit link http://<ALB DNS printed as output>/app in browser to see all the time stamps recorded.

```
Apply complete! Resources: 51 added, 0 changed, 0 destroyed.

Outputs:

albDNS = "avi-app-alb-1874219681.eu-west-1.elb.amazonaws.com"
Avinashs-MBP:writeDBAPI avinashsrivastava$ curl -X POST http://avi-app-alb-1874219681.eu-west-1.elb.amazonaws.com/app
2021-05-23 22:15:06.172057
Avinashs-MBP:writeDBAPI avinashsrivastava$ curl -X POST http://avi-app-alb-1874219681.eu-west-1.elb.amazonaws.com/app
2021-05-23 22:15:07.468924
Avinashs-MBP:writeDBAPI avinashsrivastava$ curl -X POST http://avi-app-alb-1874219681.eu-west-1.elb.amazonaws.com/app
2021-05-23 22:15:08.567516
Avinashs-MBP:writeDBAPI avinashsrivastava$ curl -X POST http://avi-app-alb-1874219681.eu-west-1.elb.amazonaws.com/app
2021-05-23 22:15:09.383439
Avinashs-MBP:writeDBAPI avinashsrivastava$ curl -X POST http://avi-app-alb-1874219681.eu-west-1.elb.amazonaws.com/app
2021-05-23 22:15:10.173715
Avinashs-MBP:writeDBAPI avinashsrivastava$ curl -X POST http://avi-app-alb-1874219681.eu-west-1.elb.amazonaws.com/app
2021-05-23 22:15:11.442211
Avinashs-MBP:writeDBAPI avinashsrivastava$ curl -X POST http://avi-app-alb-1874219681.eu-west-1.elb.amazonaws.com/app
2021-05-23 22:15:12.266034
Avinashs-MBP:writeDBAPI avinashsrivastava$ curl -X POST http://avi-app-alb-1874219681.eu-west-1.elb.amazonaws.com/app
2021-05-23 22:15:13.069396
Avinashs-MBP:writeDBAPI avinashsrivastava$ curl -X POST http://avi-app-alb-1874219681.eu-west-1.elb.amazonaws.com/app
2021-05-23 22:15:13.962218
Avinashs-MBP:writeDBAPI avinashsrivastava$
Avinashs-MBP:writeDBAPI avinashsrivastava$
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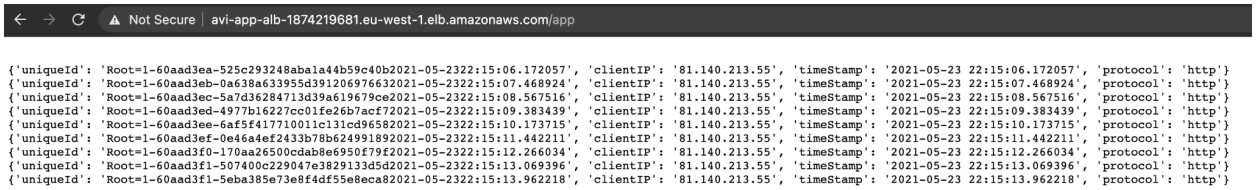

- Destroy the system

1. Check what's being destroyed

   python3 deploy_from_local.py -a planDestroy -e poc

2. Finally destroy

   python3 deploy_from_local.py -a destroy -e poc

Technology consideration

Tools:

1. Terraform as Infrastructure as Code (Iac)
2. Git for version control (github)
3. Python for automation

AWS Platform:

- Route 53
- Internet Gateway
- Virtual Private Cloud (VPC) and Subnets
- Route Tables, NACL and Security Groups.
- VPC Endpoint for DynamoDB Service
- Application Load Balancer
- Lambda
- DynamoDB
- CloudWatch
- S3
- And other services like IAM, ALB listeners, Target groups etc

Amazon Web Service's Serverless platforms is suitable for such requirement's solution, because:

1. I can avoid platform maintenance overhead in terms of
    a. Patching
    b. Scanning
    c. Upgrade and updates
    d. Life cycle management
    e. From pay as you go to pay when it runs (in milliseconds.)
2. HIghly scalable and AWS managed service.
3. Flexibility in terms of scalability and elasticity.

Choosing NoSQL DB for this requirement because it's not asking to follow a strict schema to maintain and We are looking to perform any relational activity among tables hence NoSQL is suitable as it can scale.

Technical Debt

1. Segregation of Standard Network terraform (e.g. VPC, Endpoints, Route Tables, NACLs, ALB etc) and Application specific Infrastructure (ALB Target Groups, Lambda, DynamoDB etc)

2. Flexibility to deploy the additional endpoint which is dependent on the above point.

3. Creation of a pipeline on Azure DevOps for portability.

4. Demonstration of additional regional deployment which will require a hosted zone with the specific domain.

References

- https://docs.aws.amazon.com/vpc/latest/userguide/managed-prefix-lists.html
- https://docs.aws.amazon.com/general/latest/gr/rande.html
- https://docs.aws.amazon.com/lambda/latest/dg/configuration-vpc.html
- https://aws.amazon.com/blogs/aws/new-vpc-endpoints-for-dynamodb/
- https://docs.amazonaws.cn/en_us/amazondynamodb/latest/developerguide/vpc-endpoints-dynamodb.html
- https://docs.aws.amazon.com/amazondynamodb/latest/developerguide/vpc-endpoints-dynamodb-tutorial.html
- https://aws.amazon.com/blogs/networking-and-content-delivery/lambda-functions-as-targets-for-application-load-balancers/
- https://docs.aws.amazon.com/lambda/latest/dg/monitoring-functions-access-metrics.html
- https://docs.aws.amazon.com/lambda/latest/dg/runtimes-extensions-api.html
- https://docs.aws.amazon.com/amazondynamodb/latest/developerguide/GettingStarted.Python.03.html
- https://boto3.amazonaws.com/v1/documentation/api/latest/reference/services/dynamodb.html#service-resource
- https://docs.aws.amazon.com/general/latest/gr/aws-ip-ranges.html