ASSIGNMENT 6 – CLOUD FREE FOR ALL

INTRODUCTION

This assignment focuses on developing software applications on GCP. In previous versions we have mainly focused on developing applications that utilize GCP to be able to achieve a single task. For this assignment, the focus was to utilize the GCP to build a whole application.

I have built a personalized note taking app, usable for any students and professionals alike, on storing important notes, such as lectures, meeting and so on. The application utilizes many GCP API's for its implementation and deployment. It mainly focuses on providing the most scalable and distributed method in deploying the application on the cloud. I have chosen such a basic application as to easily utilize the application development to properly demonstrate the various functionalities of GCP API's that I have used. The application is complex enough to validate the use of microservices and thus a better way to demonstrate the workings of distributed systems architecture.

The **Notes App** is built as a distributed microservices model, where each service is essentially functioning independently and can scale independently with respect to the load the application will come across. GCP provides us with multiple ways to setup distributed architecture in the cloud. One of the ways is to utilize the Cloud Run, a popular variety of hosting stateless microservices, with the help of containerization.

For this assignment, I really wanted to understand and try a different variety of containerized application, and I opted to demonstrate my understanding with a simple application utilizing Cloud Run. Cloud Run requires a variety of other GCP API's to enable CI/CD (Continuous Integration/ Continuous Deployment) which have also been utilized through this assignment.

The assignment mainly focuses on three microservices hosted in Cloud run, which renders the whole application frontend and backend layer to the user in an auto scaling manner, which will be discussed in detail in the upcoming sections.

The rest of the report will discuss on the design, implementation, performance, logs, and other weakness of such an application development.

HOW TO RUN

The application is auto set to run on GCP cloud run through and through without any manual intervention in the form of local commands. The application frontend has a cloud run initiated URL, which we can hit to interact with the application.

Notes-App front end URL: https://notes-frontend-lb6yim52dq-uk.a.run.app/

For editing and updating the application locally, the user must unzip the zipped folder into any local drive and follow the next steps.

Before starting to edit locally, the user needs to have the below requirements satisfied.

1. Python 3.7 or higher.
2. NodeJS/ npm.

Instructions to run frontend

- Navigate to the project folder: **cd Cloud_Free_for_all**
- Navigate to the frontend folder: **cd notes-frontend**
- Do the prerequisite installation of libraries: **npm install**
- Run the frontend server locally: **npm start**

The backend microservices are also running on GCP Cloud run, but if the user wishes to edit the backend microservices, they need to follow the below instructions.

Auth-service

This microservice handles the authentication required for the application such as login, register for users. For editing, this microservice:

- Navigate to the auth-service folder: **cd Authentication**
- Install the prerequisites: **pip install -r requirements.txt**
- Run the python Flask application: **python3 app.py**

Notes-service

This microservice handles the user interaction with notes. It provides the basic CRUD operations on notes, such as to create a note, edit a note, delete a note, and view a note. For editing the microservice:

- Navigate to the notes-service folder: **cd Notes**
- Install the prerequisites: **pip install -r requirements.txt**
- Run the python Flask application: **python3 app.py**

Both the above services utilize GCP firestore for handling data, thus they cannot be run locally without setting up a Gcloud SDK for my individual project. Thus, it is not advisable to run these microservices locally.

But all the above microservices can be edited, updated, and run on Gcloud run with the below commands.

For updating the frontend service and deploying in your own GCloud run environment:

- Update the necessary pages in the frontend service.
- Run the command to build a new image: **gcloud builds submit --tag gcr.io/$PROJECT:ID/notes-frontend**
- Run the command to deploy the cloud run: **gcloud run deploy --image gcr.io/$PROJECT:ID/notes-frontend --platform managed**

Similar steps can be followed to edit and deploy each of the backend microservices as well to their respective cloud run instances.

NOTE: The backend cloud run instances URL must be updated in the frontend codebase, to have functional API calls.

CLOUD API USED

In this assignment I have utilized a variety of cloud API's. These have been used for implementation as well as setting up the infrastructure to run the application and so on. The major cloud API's used are as follows.

1. **GCP Cloud Run**

Cloud Run is basically like the Cloud Functions API that was utilized in the previous assignment. Cloud Run enables the user to **Develop and deploy highly scalable containerized applications on a fully managed serverless platform**. Cloud Run deploys an image stored in the Cloud Registry for GCP (like Docker Hub), in a container which can be auto scaled with respect to load. Cloud run allows users to simply write the application in whichever language they want and utilize the ability to ship containerized application.

2. **GCP Cloud Build**

Cloud Build is a tool which can be used to **perform CI/CD pipelines for the application with ease**. Cloud Build can be utilized to setup build triggers, define custom workflow for building, testing, and deploying applications in GCP. It can also be used to deploy the application across various environments. We have used Cloud Build in specifically two methods.

- Used the cloud build cli to automatically build a microservice into an image which can be stored in the Cloud registry to be accessed from anywhere.
- Setup cloud build triggers to check for source code update in GitHub and triggering a new build for the updated microservice automatically into the cloud registry.

The cloud build effectively allows us to package our application into containers, which can be deployed and distributed to any environment allowing containerized deployment, without changing the code base involved underneath.

I have setup my code base in my personal GitHub, to initiate the triggers. The link to my GitHub repo: https://github.com/gouthamgopal/GCP_Notes_App.

3. **GCP Firestore**

Cloud Firestore allows users to develop applications utilizing **fully managed, scalable, and serverless document database**. Firestore enables users to store collections and documents in the database, utilizing the power of not having to adhere to datatypes and format. It resembles much with the popular NoSQL database MongoDB, allowing easy interaction and looking up of data with queries. I used Firestore to enable myself to store data in the form of json, for easy lookup as well as editing the data through my microservice. GCP provides easy python libraries to enable the users to interact with Firestore, which I have also utilized.

My Firestore mainly has 2 collections, **users,** and **notes.** The user's collection maintains the list of registered users, and the notes collection maintains the list of notes with each having their own user attached to the entry.

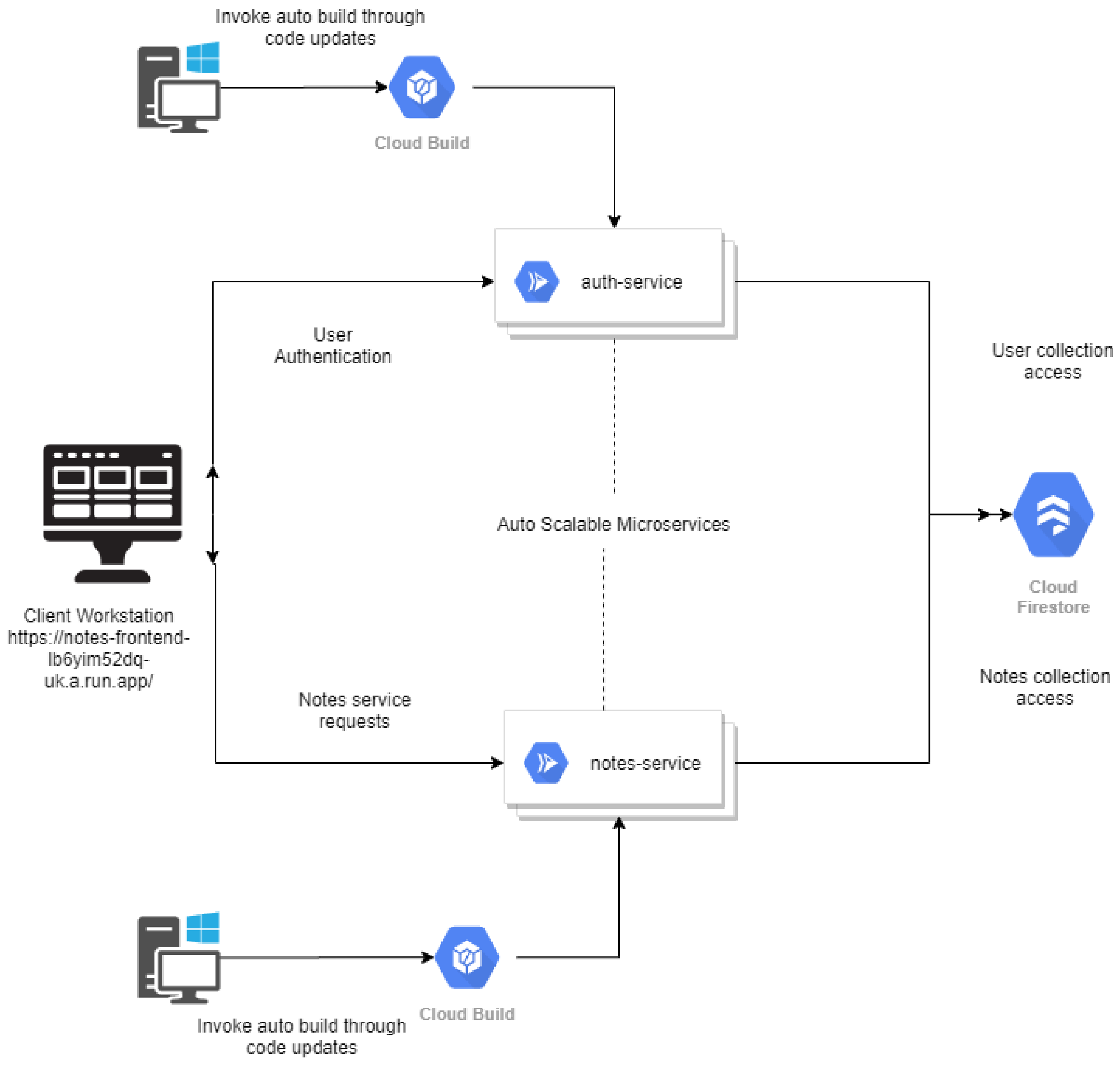
DETAILED DESIGN

The application design consists mainly of two sections, the frontend microservice and the two backend microservices along with the cloud infrastructure.

The backend design consists mainly of designing the python flask application which can interact with the cloud Firestore as well as be containerized using cloud build and shipped to cloud run for deployment.

The design basically focuses on connectivity and scalability of application with respect to user loads. For this we can imagine the application gaining multiple instances deployed through cloud run, and scaling in once the load has substantially decreased.

The application connectivity can be seen in the below diagram.


Invoke auto build through code updates
Cloud Build
auth-service
User Authentication
User collection access
Client Workstation https://notes-frontend-lb6yim52dq-uk.a.run.app/
Auto Scalable Microservices
Cloud Firestore
Notes collection access
Notes service requests
notes-service
Invoke auto build through code updates
Cloud Build

The application is mainly designed to interact with the backend microservices through HTTP requests raised by the frontend triggered with user interaction. The backend microservices utilizes the above mentioned Firestore to fetch the data and satisfy the user requirement raised by the HTTP calls.

The two major microservices were separated to follow the microservice architecture as defined by the development of distributed systems. The microservices are individual functionalities which are used to maintain only one aspect of the application. Thus, the two microservices, are deployed to maintain the separation of concerns amongst them, while assisting the frontend user interaction.

1. **auth-service cloud run microservice**

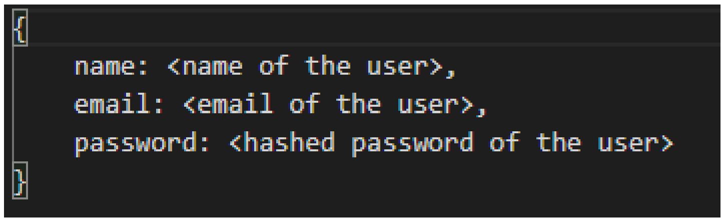
   This cloud run deployed microservice, as the name suggests is utilized for ensuring authentication happens properly within the application. It has mainly two functions/ http triggers, login, and register, which are the basic requirements for any application authentication.

   The register function interacts with the Firestore collection (users) to fetch or add the user details specified via the HTTP request.

2. **notes-service cloud run microservice**
   This cloud run deployed microservice, is utilized for ensuring the basic CRUD operations for notes, in the application. The cloud run service is invoked during the add, update, delete operations initiated by the client. The microservice utilizes Firestore similarly to the above function. It has several endpoints, targeting each individual functionality for the user. Various user requests may come to these different endpoints, which will satisfy the user requirements or raise an error with respect to the data specified by the user.

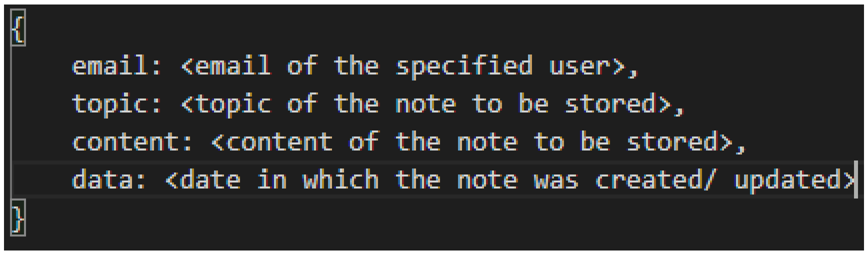
The **cloud Firestore** as mentioned above, is utilized for storing the user related data on the cloud. The microservices use a Firestore specific API to interact with the Firestore DB, which is a NoSQL database. As the application is designed to store data as a key value pair, we have created collections to maintain the requirement. Each collection can contain multiple sets of documents inside, which can be the unordered data in json format.

The format for storing user data in Firestore is as below:



```
{
    name: <name of the user>,
    email: <email of the user>,
    password: <hashed password of the user>
}
```

The format for storing notes data for each user is as follows:



```
{
    email: <email of the specified user>,
    topic: <topic of the note to be stored>,
    content: <content of the note to be stored>,
    data: <date in which the note was created/ updated>
}
```

The Firestore client can access these documents based on the query specified in the microservice. An example of such a query to fetch a specific note for a user is:

```
docs = notesCollection.where(u'email', u'==', email).where(u'topic', u'==', topic).stream()
```

Such queries provide the reference object of the Firestore objects, which can then be utilized to aggregate the actual data.

IMPLEMENTATION

The implementation of the application can be easily explained by utilizing a live example from the beginning of a user creation to updation of a note added by the user. For this implementation demo, I shall utilize the already deployed frontend microservice url: **https://notes-frontend-lb6yim52dq-uk.a.run.app/**

The application is implemented using React as the front end and python Flask application for the backend microservices. As mentioned earlier, the application has 2 microservices, that are being used to provide request endpoints for both authentication and CRUD operations for notes.

The application frontend consists mainly of 5 pages, including a login, register, view notes, edit note as well as add note page. We shall cover each page as well as the backend functionality used for each of the page below.

1. The application starts off by routing to the home component. If the user is not logged in previously to the browser, the application will re route itself to the login page, as seen below (Fig 1).
   The user can enter the email and password to login to the application or use the register button to go to the register page for new registration.
2. The register screen allows the user to register into the application, by entering few details such as email, name, and password. All necessary error handling has been done before registration.

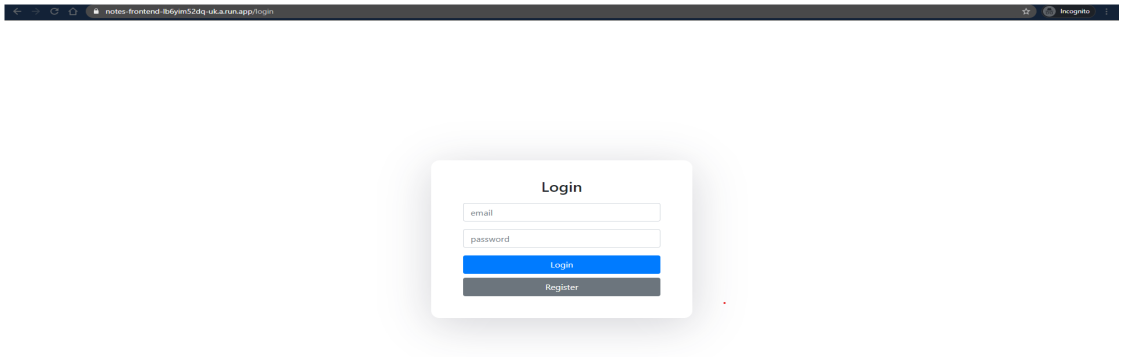


Figure 1: Login Screen

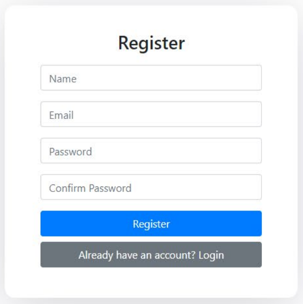
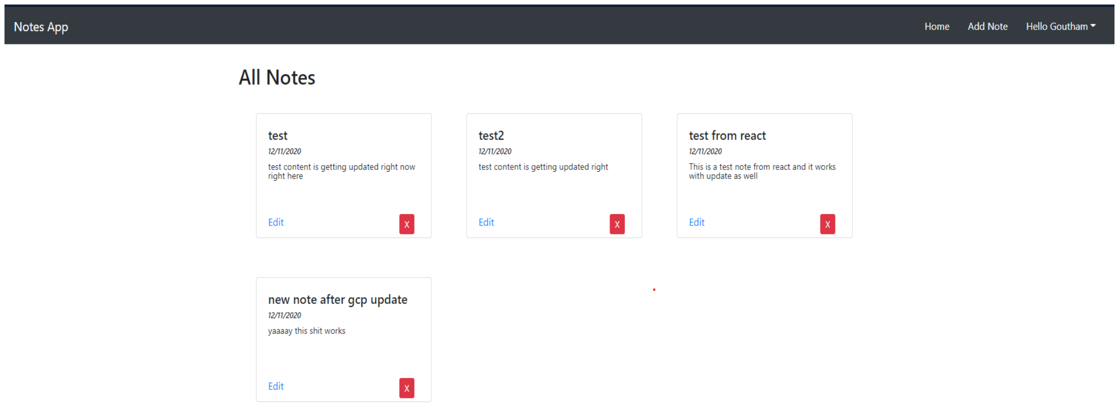


Figure 2: Register Screen

3. Once, the user is logged in, they will be taken to the home screen, where they can view all the notes that they have created till now.



test
12/11/2020
test content is getting updated right now right here

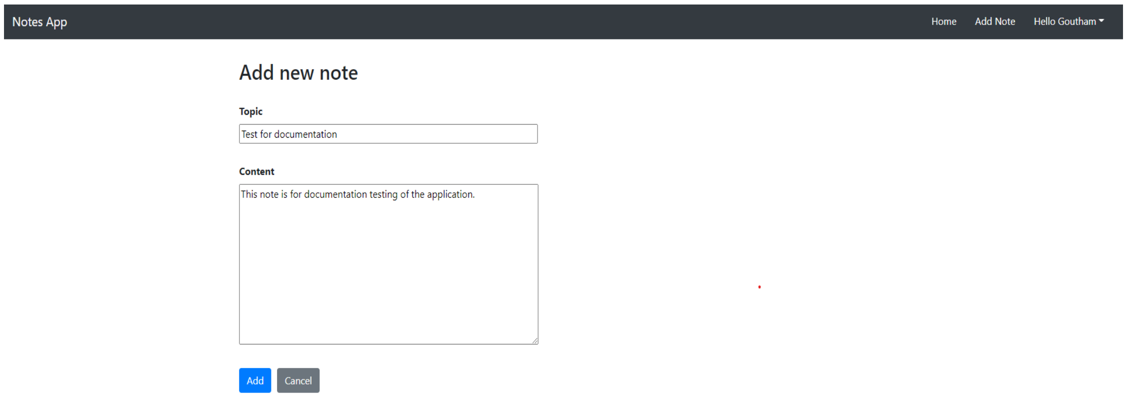
test2
12/11/2020
test content is getting updated right

test from react
12/11/2020
This is a test note from react and it works with update as well

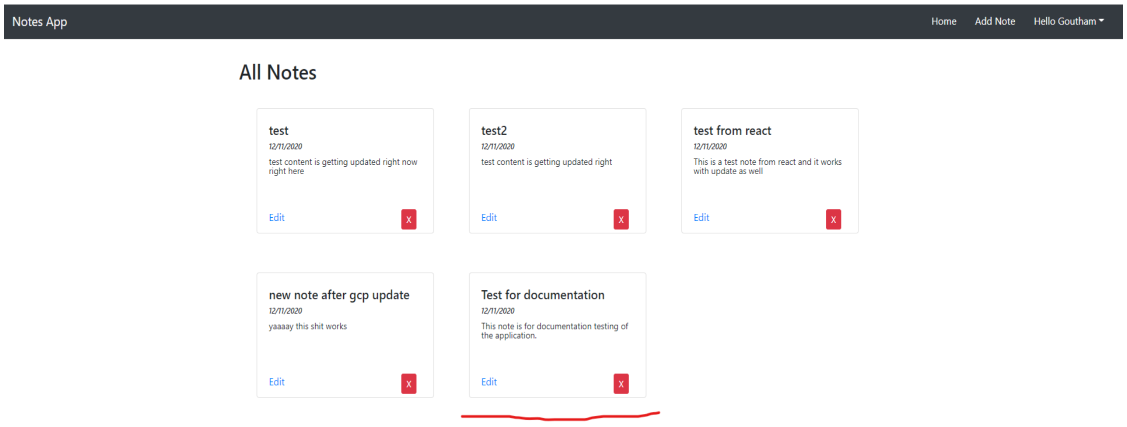
new note after gcp update
12/11/2020
yaaaay this shit works

As you can see, all the notes are well placed on the screen, with the user having the ability to navigate through each note, as well as edit or delete the notes that they want.
Each screen will also have a top navigation bar, that they can use to navigate to different pages in the application. The user can click on their name on the top right which will show an option to Logout from the application.

4. The add feature of a new note can be done by clicking the Add Note button on the top right, which will take the user to the add note page as shown below.


Notes App
Home Add Note Hello Goutham
Add new note
Topic
Test for documentation
Content
This note is for documentation testing of the application.
Add Cancel

Once the user adds a new note, they will be re routed back to the main screen, where they can see the new note added to the list of notes. All notes are placed with the topic of the note, the date of creation/ updation of the note and the content of the note.


Notes App
Home Add Note Hello Goutham
All Notes

test
12/11/2020
test content is getting updated right now right here
Edit X

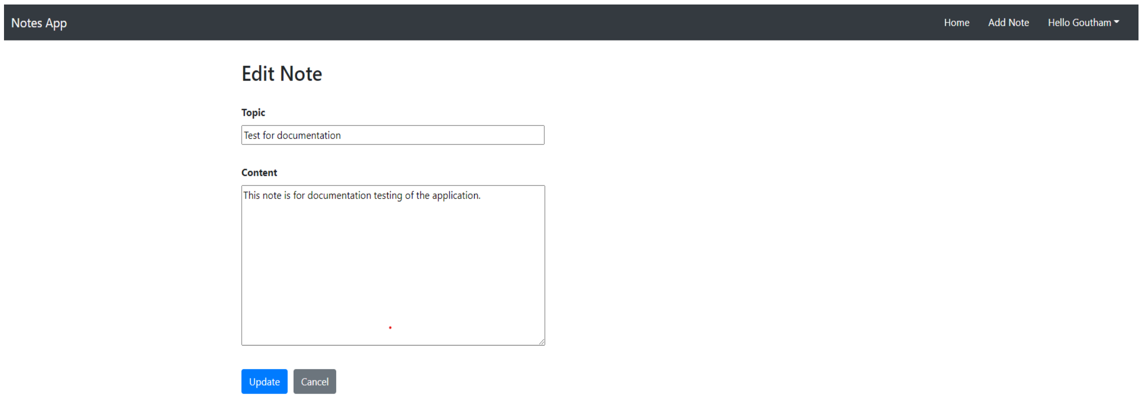
test2
12/11/2020
test content is getting updated right
Edit X

test from react
12/11/2020
This is a test note from react and it works with update as well
Edit X

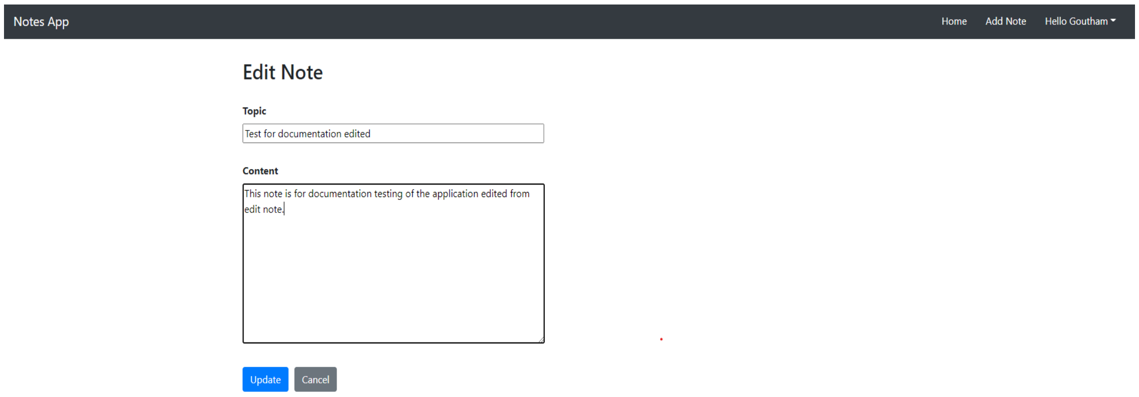
new note after gcp update
12/11/2020
yaaaay this shit works
Edit X

Test for documentation
12/11/2020
This note is for documentation testing of the application.
Edit X

5. If the user wishes to edit any document, they can do so by clicking the edit button on the card, which will take them to the edit screen as shown below.


Notes App
Home Add Note Hello Goutham
Edit Note
Topic
Test for documentation
Content
This note is for documentation testing of the application.
Update Cancel

Here, the user can change the topic as well as the content and see that the notes reflect the updation as well on the home screen.



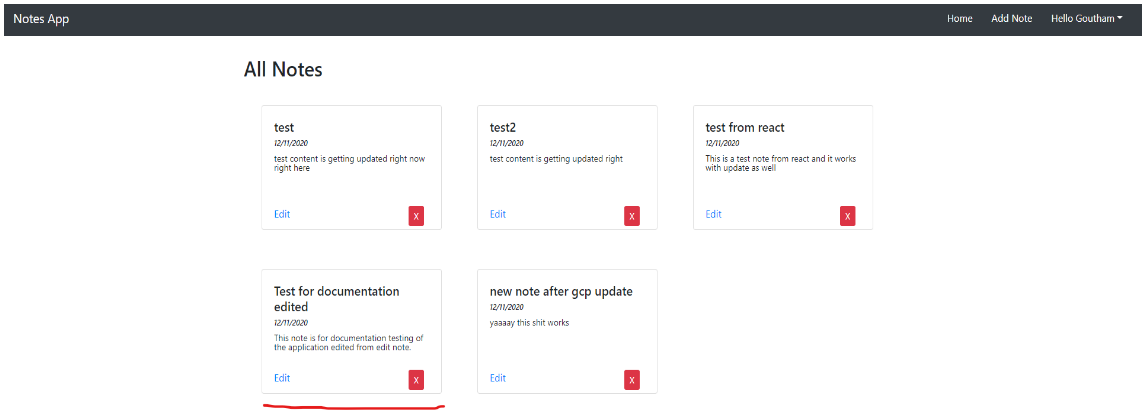
Edit Note

Topic

Test for documentation edited

Content

This note is for documentation testing of the application edited from edit note.



All Notes

test 12/11/2020 test content is getting updated right now right here Edit x	test2 12/11/2020 test content is getting updated right Edit x	test from react 12/11/2020 This is a test note from react and it works with update as well Edit x
Test for documentation edited 12/11/2020 This note is for documentation testing of the application edited from edit note. Edit x	new note after gcp update 12/11/2020 yaaaay this shit works Edit x	

6. The user can also delete a note and they will just disappear from all notes view for the user.

Microservices implementation overview

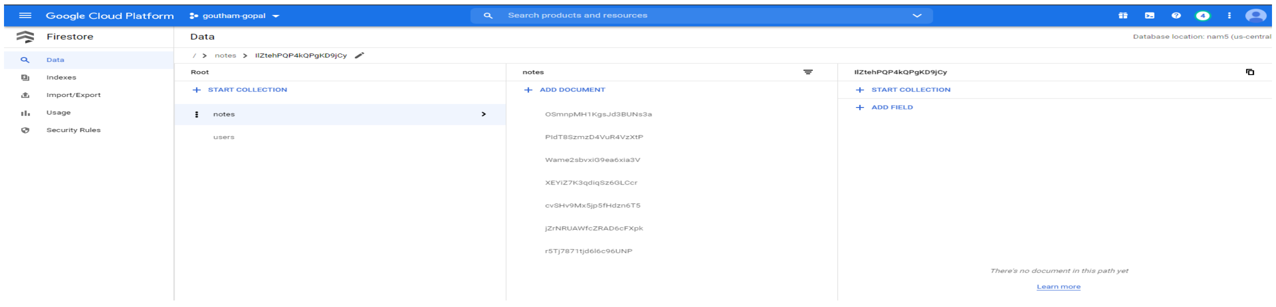
The authentication cloud run microservice, has two endpoints: /login and /register.

These endpoints as their name suggests work towards login or registration of any user to the system. The service utilizes the Firestore collection named ‘users’ to handle the database for the application, managed via a python API reference for the Firestore.

The notes cloud run microservice, has 4 endpoints: /fetch, /edit, /delete and /add.

These endpoints also work as their name suggests for each user, where the requests send in the data as well as the user jwt token created when the user was logged in to the system. This microservice also utilizes the Firestore to keep track of the database of notes for each user.

The Firestore collection is as below.



Data

Database location: nam5 (us-central

/ > notes > IlZtehPQP4kQPgKD9jCy

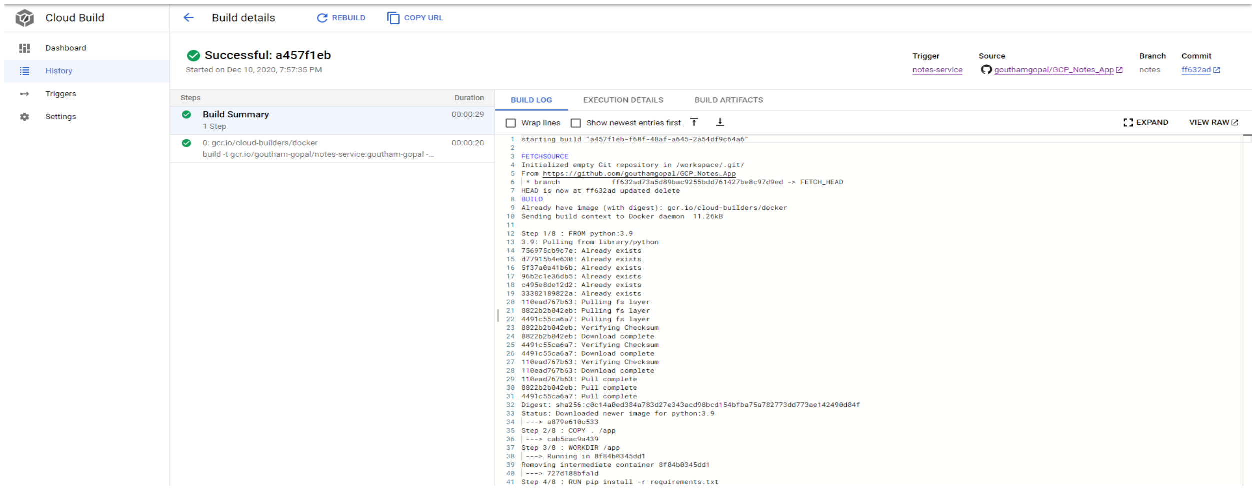
Root: notes, users

notes:
- OSmnpMH1KgsJd3BUNs3a
- PldT8SzmzD4VuR4VzXtP
- Wame2sbvxiG9ea6xia3V
- XEYiZ7K3qdiqSz6GLCcr
- cvSHv9Mx5jp5fHdzn6T5
- jZrNRUAWfcZRAD6cFXpk
- r5Tj7871tjd6l6c96UNP

IlZtehPQP4kQPgKD9jCy

There's no document in this path yet

All the implementation focuses on containerized application deployment, which will help us maintain the updates as well as routing of the application in a simple manner. We can also see the build trigger logs once we update the application in GitHub as shown below.



Successful: a457f1eb
Started on Dec 10, 2020, 7:57:35 PM

Trigger	Source	Branch	Commit
notes-service	gouthamgopal/GCP_Notes_App	notes	ff632ad

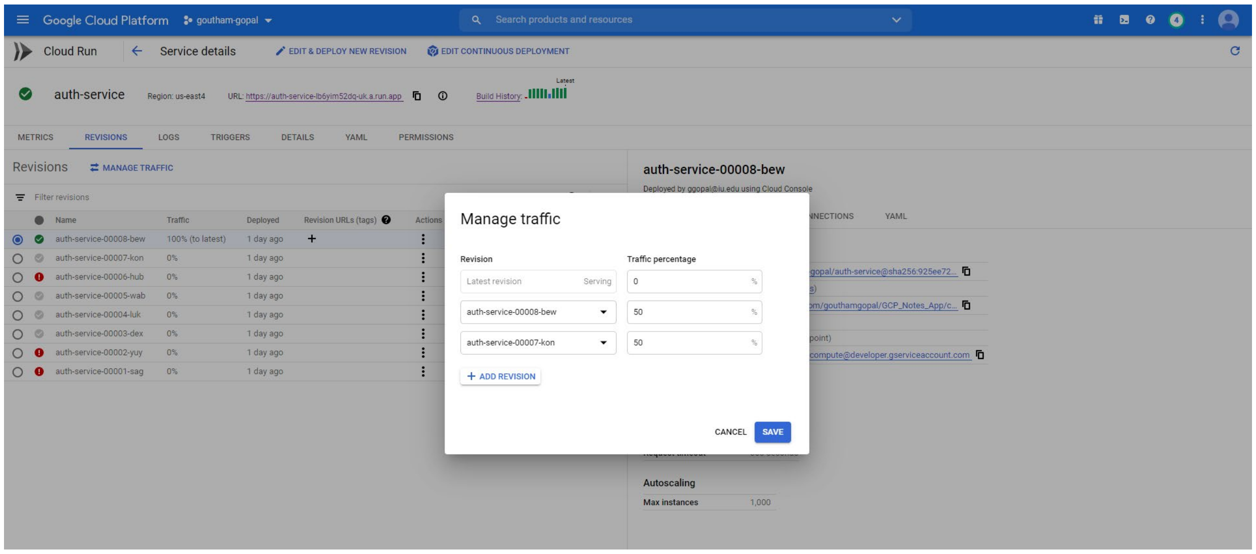
Steps	Duration
Build Summary 1 Step	00:00:29
0: gcr.io/cloud-builders/docker build -t gcr.io/goutham-gopal/notes-service:goutham-gopal -...	00:00:20

```
starting build "a457f1eb-f68f-48af-a645-2a54df9c64a6"

FETCHSOURCE
Initialized empty Git repository in /workspace/.git/
From https://github.com/gouthamgopal/GCP_Notes_App
 * branch            ff632ad73a5d89bac9255bdd761427be8c97d9ed -> FETCH_HEAD
HEAD is now at ff632ad updated delete
BUILD
Already have image (with digest): gcr.io/cloud-builders/docker
Sending build context to Docker daemon  11.26kB

Step 1/8 : FROM python:3.9
3.9: Pulling from library/python
756975cb9c7e: Already exists
d77915b4e630: Already exists
5f37a0a41b6b: Already exists
96b2c1e36db5: Already exists
c495e8de12d2: Already exists
33382189822a: Already exists
110ead767b63: Pulling fs layer
8822b2b042eb: Pulling fs layer
4491c55ca6a7: Pulling fs layer
8822b2b042eb: Verifying Checksum
8822b2b042eb: Download complete
4491c55ca6a7: Verifying Checksum
4491c55ca6a7: Download complete
110ead767b63: Verifying Checksum
110ead767b63: Download complete
110ead767b63: Pull complete
8822b2b042eb: Pull complete
4491c55ca6a7: Pull complete
Digest: sha256:c0c14a0ed384a783d27e343acd98bcd154bfba75a782773dd773ae142490d84f
Status: Downloaded newer image for python:3.9
 ---> a879e610c533
Step 2/8 : COPY . /app
 ---> cab5cac9a439
Step 3/8 : WORKDIR /app
 ---> Running in 8f84b0345dd1
Removing intermediate container 8f84b0345dd1
 ---> 727d188bfa1d
Step 4/8 : RUN pip install -r requirements.txt
```

The cloud run also allows the microservices to contain multiple images active at the same time. This is a useful feature while implementing complex applications. We can take care of the routing and what percentage needs to be routed to which image from the section as shown below.



auth-service   Region: us-east4   URL: https://auth-service-lb6yim52dq-uk.a.run.app

Revisions

		Name	Traffic	Deployed	Revision URLs (tags)	Actions
◉	✓	auth-service-00008-bew	100% (to latest)	1 day ago	+	⋮
○	✓	auth-service-00007-kon	0%	1 day ago		⋮
○	!	auth-service-00006-hub	0%	1 day ago		⋮
○	✓	auth-service-00005-wab	0%	1 day ago		⋮
○	✓	auth-service-00004-luk	0%	1 day ago		⋮
○	✓	auth-service-00003-dex	0%	1 day ago		⋮
○	!	auth-service-00002-yuy	0%	1 day ago		⋮
○	!	auth-service-00001-sag	0%	1 day ago		⋮

auth-service-00008-bew
Deployed by ggopal@iu.edu using Cloud Console

gopal/auth-service@sha256:925ee72...
s)
om/gouthamgopal/GCP_Notes_App/c...
point)
compute@developer.gserviceaccount.com

Autoscaling

Max instances	1,000

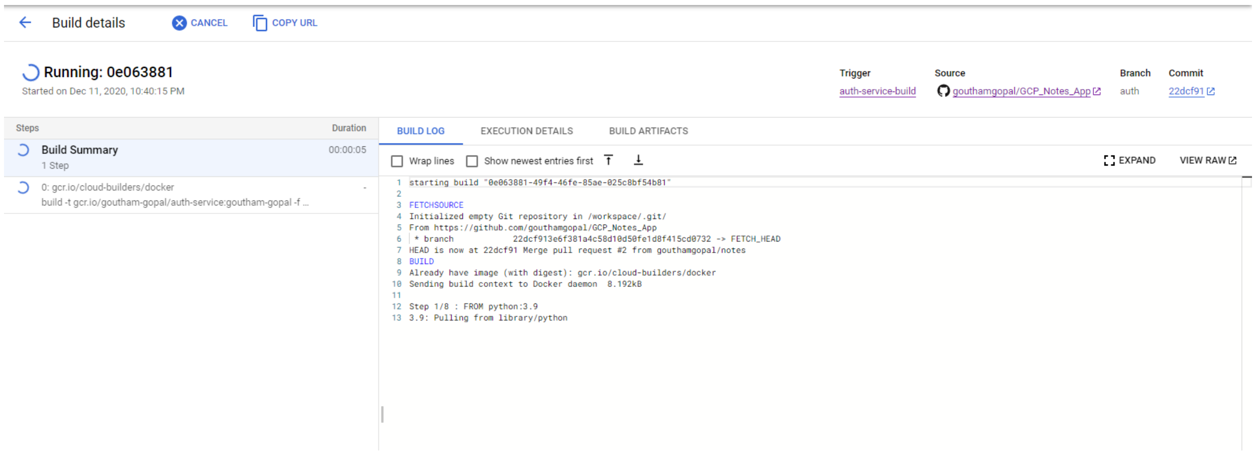
Manage traffic

Revision	Traffic percentage
Latest revision · Serving	0 %
auth-service-00008-bew	50 %
auth-service-00007-kon	50 %

PERFORMANCE

The performance for the application can be measured in multiple ways. The performance for any containerized application basically is measured by the uptime the application can provide even during service failures and updation to the system. As we know that containerized images get pushed to the microservice automatically through CI/CD, the cloud run maintains the old service active for the users to send requests to until the new version is fully running without any error.

With the application, that I have developed, I could never notice any service failure during server crash or even during updating to a new revision that I have just updated. The services' previous containerized image would still be active during updation as seen below.



Build details · CANCEL · COPY URL

Running: 0e063881
Started on Dec 11, 2020, 10:40:15 PM

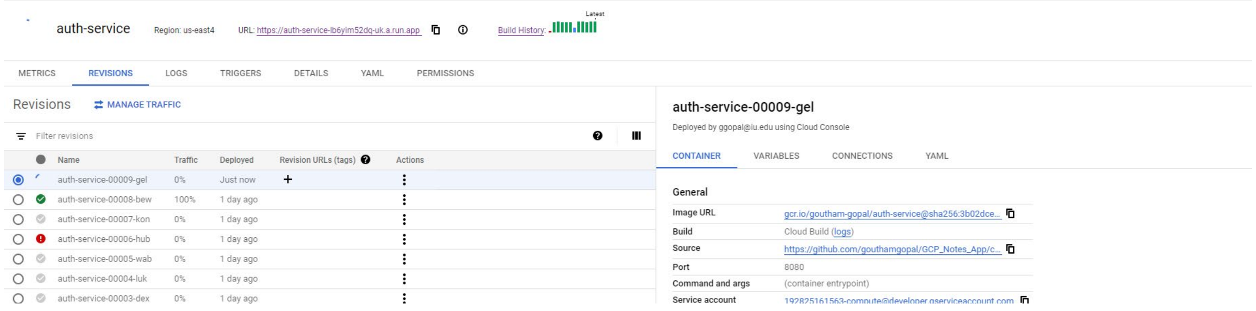
Trigger	Source	Branch	Commit
auth-service-build	gouthamgopal/GCP_Notes_App	auth	22dcf91

Steps	Duration
Build Summary 1 Step	00:00:05
0: gcr.io/cloud-builders/docker build -t gcr.io/goutham-gopal/auth-service:goutham-gopal -f ...	-

```
starting build "0e063881-49f4-46fe-85ae-025c8bf54b81"

FETCHSOURCE
Initialized empty Git repository in /workspace/.git/
From https://github.com/gouthamgopal/GCP_Notes_App
 * branch            22dcf913e6f381a4c58d10d50fe1d8f415cd0732 -> FETCH_HEAD
HEAD is now at 22dcf91 Merge pull request #2 from gouthamgopal/notes
BUILD
Already have image (with digest): gcr.io/cloud-builders/docker
Sending build context to Docker daemon  8.192kB

Step 1/8 : FROM python:3.9
3.9: Pulling from library/python
```



auth-service   Region: us-east4   URL: https://auth-service-lb6yim52dq-uk.a.run.app   Build History:

		Name	Traffic	Deployed	Revision URLs (tags)	Actions
●		auth-service-00009-gel	0%	Just now	+	⋮
○	✓	auth-service-00008-bew	100%	1 day ago		⋮
○	✓	auth-service-00007-kon	0%	1 day ago		⋮
○	!	auth-service-00006-hub	0%	1 day ago		⋮
○	✓	auth-service-00005-wab	0%	1 day ago		⋮
○	✓	auth-service-00004-luk	0%	1 day ago		⋮
○	✓	auth-service-00003-dex	0%	1 day ago		⋮

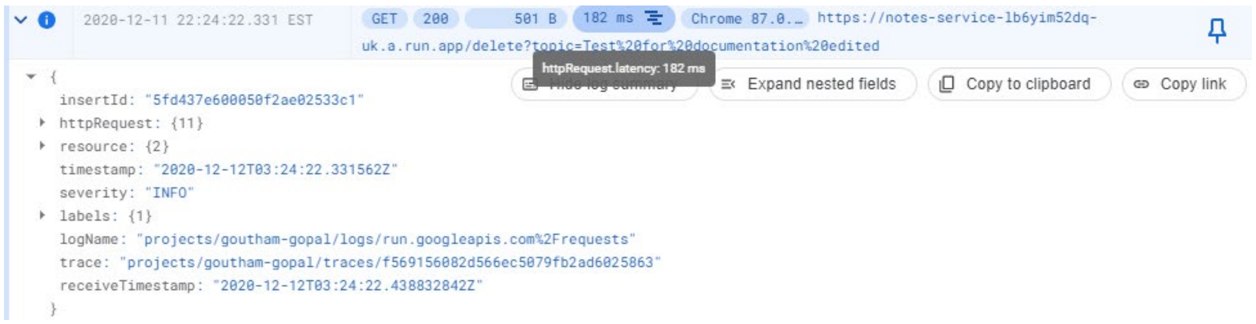
auth-service-00009-gel
Deployed by ggopal@iu.edu using Cloud Console

General

Image URL	gcr.io/goutham-gopal/auth-service@sha256:3b02dce...
Build	Cloud Build (logs)
Source	https://github.com/gouthamgopal/GCP_Notes_App/c...
Port	8080
Command and args	(container entrypoint)
Service account	192825161563-compute@developer.gserviceaccount.com

As we can see the old service is still active as the new one is being prepared to switch after an update.

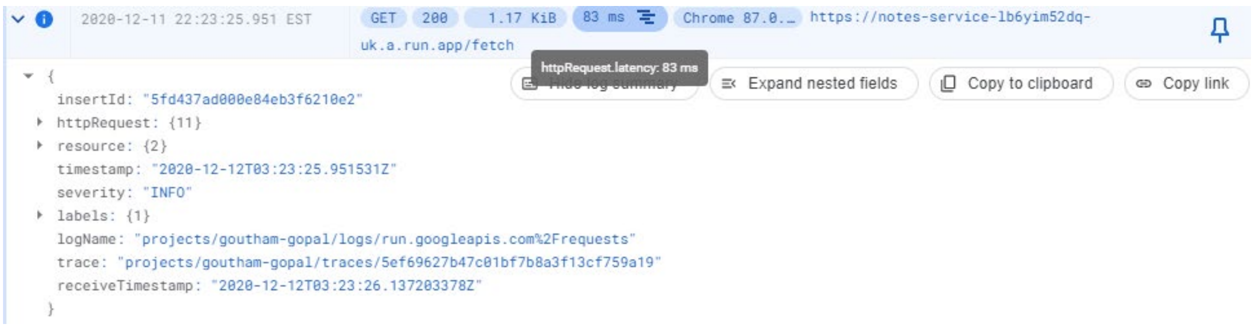
We can also measure the performance of the application by checking the logs for the application to see how much time it took to satisfy each request, as shown below for a few requests we made earlier.



```
2020-12-11 22:24:22.331 EST   GET  200   501 B  182 ms  Chrome 87.0…  https://notes-service-lb6yim52dq-
uk.a.run.app/delete?topic=Test%20for%20documentation%20edited
```

```
{
  insertId: "5fd437e600050f2ae02533c1"
  httpRequest: {11}
  resource: {2}
  timestamp: "2020-12-12T03:24:22.331562Z"
  severity: "INFO"
  labels: {1}
  logName: "projects/goutham-gopal/logs/run.googleapis.com%2Frequests"
  trace: "projects/goutham-gopal/traces/f569156082d566ec5079fb2ad6025863"
  receiveTimestamp: "2020-12-12T03:24:22.438832842Z"
}
```

Images show the time taken by the cloud run microservice to respond to the request from the frontend. As we can see they have very low latency and can be scaled once the server requests/sec increase heavily.



```
2020-12-11 22:23:25.951 EST   GET   200   1.17 KiB   83 ms   Chrome 87.0…   https://notes-service-lb6yim52dq-uk.a.run.app/fetch
{
  insertId: "5fd437ad000e84eb3f6210e2"
  httpRequest: {11}
  resource: {2}
  timestamp: "2020-12-12T03:23:25.951531Z"
  severity: "INFO"
  labels: {1}
  logName: "projects/goutham-gopal/logs/run.googleapis.com%2Frequests"
  trace: "projects/goutham-gopal/traces/5ef69627b47c01bf7b8a3f13cf759a19"
  receiveTimestamp: "2020-12-12T03:23:26.137203378Z"
}
```

LEARNING FROM ASSIGNMENT

This assignment was targeted for extensive learning about deploying cloud application to the GCP as well as creative learning through the process. For this intention, I made myself learn about the different ways in which we can deploy applications to the cloud and tried to learn a new way to upload and sustain distributed application through GCP. The major advantage of deploying microservices is the ability to distribute the application and re deploy anywhere without any issues with the base hardware specifications. The image will work with any containerization tool and will provide the same result.

I have utilized the remaining GCP credits to understand and demonstrate how we can achieve CI/CD for a basic microservice architecture-based application.

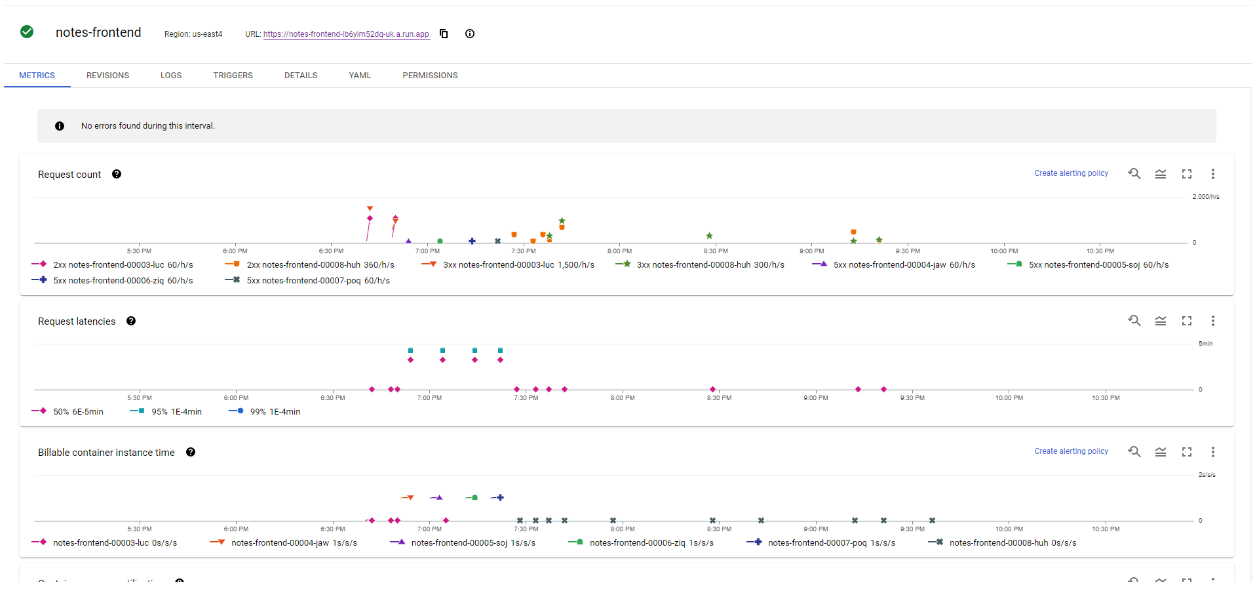
I have also understood how we can take any application, convert it into a microservice architecture by splitting the functionality and grouping similar services into a single microservice. This will allow us to containerize such microservices by utilizing various containerization methods like Docker, Cloud Build and so on. These images can then be deployed to any container application supported environment such as Cloud run or GKE for that matter.

The assignment has also taught me to have a better understanding on the concepts of image revisions as well as the ability to route the requests to multiple revisions as explained in the above section. This ability to enable us to provide with user's different types of functionality from the same endpoint. These can be used for user-testing of a new functionality and other features as well.

It has also made me learn about how we can work with scaling and how we can control these scaling factors for each of the microservices. The cloud run in GCP, is like the Cloud functions API, where GCP will automatically handle the scale up and scale in of each microservice with respect to load. But Cloud run enables us to have a more detailed view on the requests and other parameters that relates to the scaling of the microservice as shown below.

These metrics enables us to understand how our app is performing better than how we could visualize while using Cloud functions. This better understanding also enables us to make scaling decisions on our own for our microservice, if we want to have manual scaling setup for the microservice.

I also got an opportunity to understand how we can utilize NoSQL databases like Cloud Firestore and be able to store data as collections and documents rather than a primitive RDBMS perspective. This enables us to easily store the json data that the request receives from the frontend as well as enables easy interaction with the data without much conversion compared to the tabular data formatting from RDBMS.


notes-frontend
Region: us-east4
URL: https://notes-frontend-lb6yim52dq-uk.a.run.app
METRICS
REVISIONS
LOGS
TRIGGERS
DETAILS
YAML
PERMISSIONS
Request count
Create alerting policy
2,000/h/s
0
5:30 PM
6:00 PM
6:30 PM
7:00 PM
7:30 PM
8:00 PM
8:30 PM
9:00 PM
9:30 PM
10:00 PM
10:30 PM
2xx notes-frontend-00003-luc 60/h/s
2xx notes-frontend-00008-huh 360/h/s
3xx notes-frontend-00003-luc 1,500/h/s
3xx notes-frontend-00008-huh 300/h/s
5xx notes-frontend-00004-jaw 60/h/s
5xx notes-frontend-00005-soj 60/h/s
5xx notes-frontend-00006-ziq 60/h/s
5xx notes-frontend-00007-poq 60/h/s
Request latencies
5min
0
50% 6E-5min
95% 1E-4min
99% 1E-4min
Billable container instance time
Create alerting policy
2s/s/s
0
notes-frontend-00003-luc 0s/s/s
notes-frontend-00004-jaw 1s/s/s
notes-frontend-00005-soj 1s/s/s
notes-frontend-00006-ziq 1s/s/s
notes-frontend-00007-poq 1s/s/s
notes-frontend-00008-huh 0s/s/s

No errors found during this interval.

CONCLUSION

I have learnt a lot of useful techniques and gained a lot of knowledge developing a software application and using GCP to deploy it. The assignment has made me realize how and when to opt for serverless application as well as something like Cloud run, which is also serverless but with more control for users.

I have utilized my learnings to produce a simple application which talks via HTTP requests to microservices and produces output. Through the process I have also come across asynchronous requests that can be setup by using Google Pub Sub. This type of asynchronous system can be used for a data pipeline application, which is how we can reform data-oriented applications in the future.