UNSW SYDNEY

University of New South Wales

Software Engineering Workshop 3

SENG3011

DESIGN DOCUMENT

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1.0 Design Summary

For this project, our team was prescribed the CDC as its data source. The main requirements of the specification were the development of an API in Stage 1 and a web-based platform which contributes to EpiWATCH in Stage 2. This document mainly focuses on the design of the Stage 1 API. It explains the tech stack chosen for each different component of stage and the design decisions agreed upon by the team, including justification to why we chose the tech stack as below. Research regarding other possible components on the tech stack are made present along with comparisons between them.

2.0 Software Architecture

The following section explains each software component that will make up the first stage of this application. Including the tech stacks, the research, and the justification to why these stacks were chosen. This comparison are made based on criteria the team believed are the most important to consider given our time frame and budget.

2.1 Web Scraper Design

2.1.1 General Design

The web scraper is the program responsible for receiving information from the CDC and storing it in an ideal format in our chosen database. This scraping operation will occur as follows:

- The 'US Outbreak RSS' feed will be scraped every hour.
- The main outbreaks page will be scraped every hour.

The RSS feed was chosen as it exposes all the US-based outbreaks in a very readable format, to which further links to other pages where data can be scraped from.

However, as only US outbreaks are covered by the RSS feed, the web scraper will also periodically scrape the main outbreaks page, which contains international outbreaks, every hour. An hour-long period was deemed suitable as reports on the CDC are seldom published. Thus, the period is conservative enough to save on costs and prevent overloading the CDC with requests yet frequent enough to obtain report data in a reasonable timeframe. The exact time of day are not present within the CDC reports meaning that the time frame to which they are uploaded in should also not be important enough to consider

After scraping, the outbreak information will be processed by the scraper into a format suitable for the outbreaks database and stored within the database. Figure 1 displays a tentative ER diagram for the database and the details in which we are deciding to store.

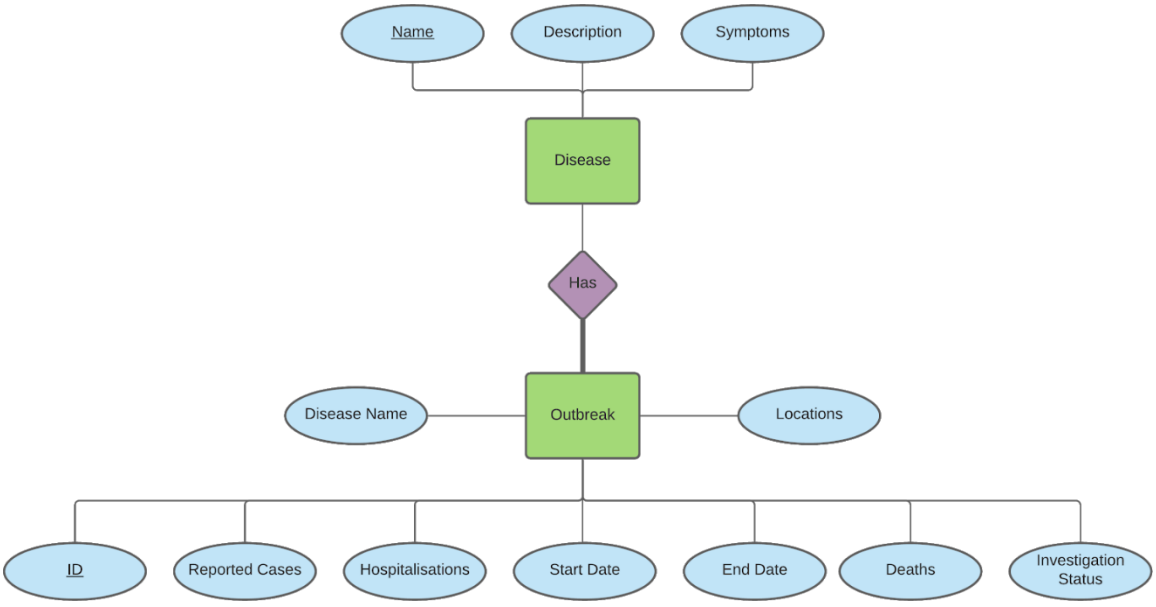
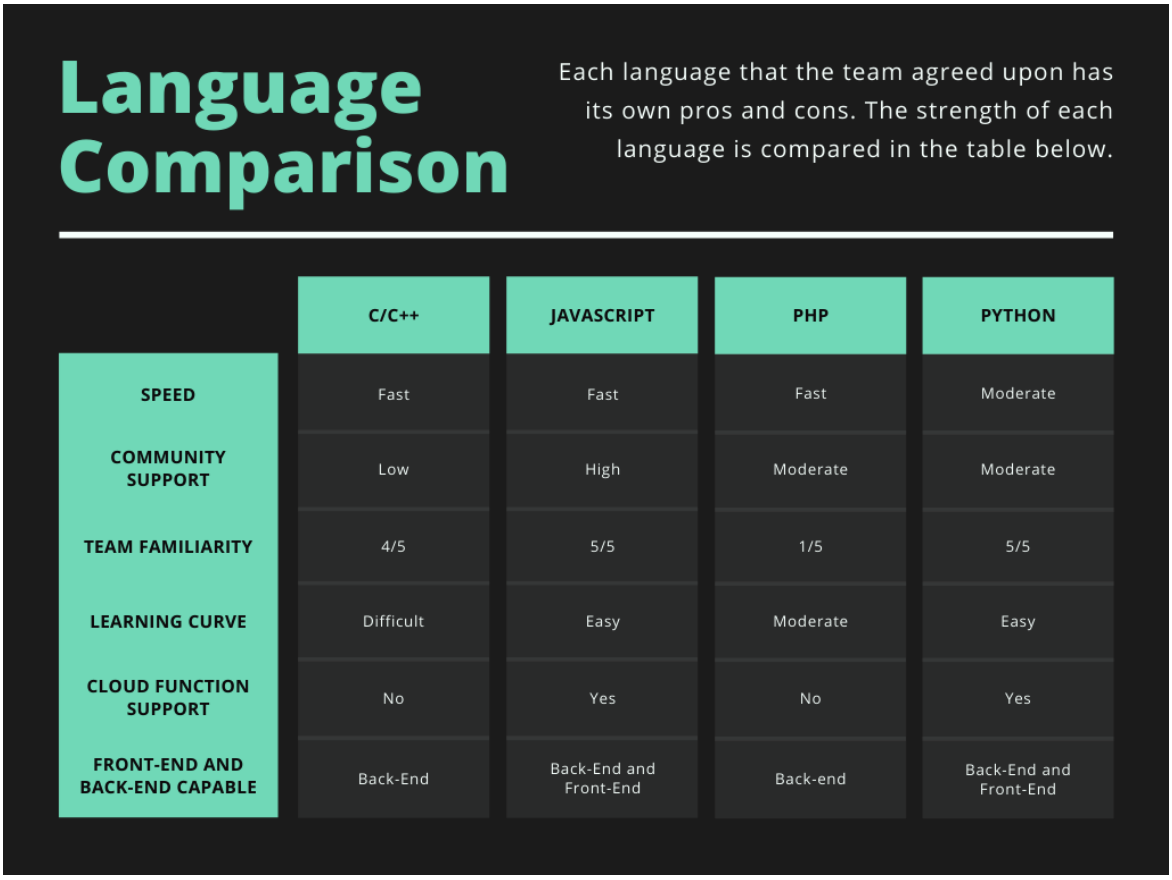


Figure 1: ER Diagram of Outbreak Database

2.1.2 Tech Stack: Language

In researching the development language, our team decided on a number of key factors: speed, community support, familiarity between group members, the learning curve, and cloud functionality. Ease of use as a web scraper was also considered.



	C/C++	JAVASCRIPT	PHP	PYTHON
SPEED	Fast	Fast	Fast	Moderate
COMMUNITY SUPPORT	Low	High	Moderate	Moderate
TEAM FAMILIARITY	4/5	5/5	1/5	5/5
LEARNING CURVE	Difficult	Easy	Moderate	Easy
CLOUD FUNCTION SUPPORT	No	Yes	No	Yes
FRONT-END AND BACK-END CAPABLE	Back-End	Back-End and Front-End	Back-end	Back-End and Front-End

Figure 2: Comparison chart of all language choice

Ultimately, Python was chosen as it's the language the team is most familiar with and has the most experience with. JavaScript was considered due to similar familiarity, but the library prevalence and support led us to choosing Python in the end. C/C++ does not have good support for web crawler development, PHP is a language that no members on the team have experience in, and while JavaScript is best suited when dealing with basic web scraping projects, scraping large scale data from CDC is not advisable. After selecting Python as our language to program, we decided we would incorporate each of the major scraping libraries (Scrapy, BeautifulSoup4, and Selenium), utilising the strengths of each of them. The strengths and how we will use each of the libraries is detailed below:

Python Libraries	Strengths	Uses
Scrapy	• Easily extensible • Built-in HTML and CSS data extraction tools • Memory and processing power efficient • Fast • Strong support for web-crawlers	Will focus on crawling between the various pages of diseases.
BeautifulSoup4	• Shallow learning curve, reducing the time needed for the team to learn the library • Easily extract data out of the requested HTML • Comprehensive documentation • Strong community support	BS4 HTML parser will be useful to quickly gather all the details required of the report and given how simple it is, it will aid in development
Selenium	• Automates testing for web applications • Beginner friendly • Has built in tools to mimic human interaction which allows us to have precise control over accessing the different web pages we need	This will be used adjacent to Scrapy to crawl the CDC outbreak page, given its precise control over a webpage

Figure 3: Python Libraries with their strength and uses in our project

2.1.3 Tech Stack: Deployment

Regarding the platform used to deploy the web scraper, the team decided that serverless cloud options would be most ideal. Given that the web scraper would only run when scraping and runs periodically every hour, having a serverless architecture where the program is only executed for as long as it needs to is economical. The team had a general lack of experience with cloud computing, so familiarity with each technology wasn't a main factor. Thus, we narrowed down the choices to: Amazon Web Services's (AWS) EC2 and Lambda, and Google Cloud Platform's (GCP) Cloud Run and Cloud Function as they were the most popular and documented serverless cloud options available.

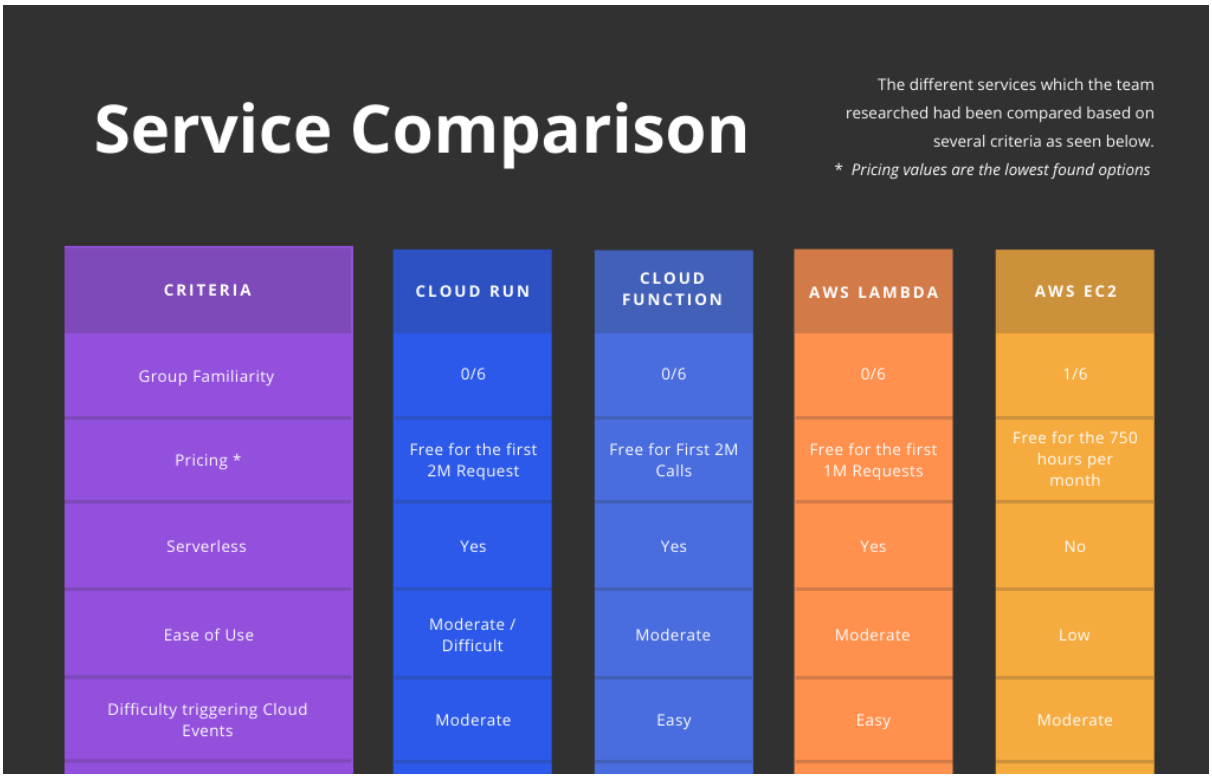


Figure 4: Comparison Table of Cloud Solution to host the Web Scraper

Cloud Function was the one ultimately chosen. We saw that GCP provided the most user-friendly UI, thus lowering the barrier to entry. Additionally, GCP also offered a helpful $300 free credit for the first 90 days as well as a money cap for some of its cloud services, making the platform seem more economical in comparison to AWS, which would immediately charge you open breaching the free tier cap. Thus, our team leaned towards a choice between the two GCP products: Cloud Run and Function.

The reason Cloud Function was chosen over Cloud Run for the following reasons:

- Cloud Function is more optimised than Cloud Run in being triggered by cloud events, specifically what the web scraper requires.
- Cloud Run is more difficult to use than Cloud Function as it requires knowledge of Docker Containers.
- Cloud Functions is more light-weight and faster than Cloud Run.

The comparison table from Google Cloud Tech in Figure 5. further showed the team that the optimal use of Cloud Functions is for data processing and 'triggered by cloud event' use cases.

Serverless Use Cases	Cloud Run	Cloud Functions	App Engine
Build a web app			
Web app			✓
HTTP services	✓		
Developing APIs			
API for web & mobile backends	✓		✓
Internal APIs and services	✓		✓
Data Processing	✓		
Automation			
Workflow & orchestration	✓	✓	
Triggered by cloud events		✓	
Connecting Cloud Services		✓	

Figure 5: Comparison Table of Google Serverless Use Cases (Source: Google Cloud Tech, 2020)

In order to schedule the Web Scraper to run every hour, we shall use Cloud Scheduler, another service on GCP, to do this easily.

2.1.4 Tech Stack: Database

In evaluating what database to use our team compared DB services hosted on GCP as it is the deployment platform we are already working with. Figure 6. illustrates this comparison:

Database	Team Familiarity	Price	Querying Capability	Ideal Use Cases
Firestore	1/5	- Mainly charges on writes/reads/deletes - Free Spark Tier is suitable.	Advanced	- Very large data sets - Storing complex, hierarchical data - Advanced querying, sorting, transactions
Firebase Realtime Database	0/5	- Charges only on bandwidth and storage but at a higher rate. - Free Spark Tier is suitable.	Basic	- Data sets that are changed often - Synchronising data - Basic querying - Frequent updates
Google Cloud Storage	0/5	- Charges based on usage. - Not free.	Advanced	- Storing file-like data (e.g. images, binaries, etc.)

Figure 6: Comparison Table of Google Cloud Database Solution

Given that our database will only be occasionally updated, we opted for Firestore. Based on our research it seemed easy to use, was the cheapest of all available options, and is ideal for storing lots of data that is infrequently updated. Google Cloud Storage was immediately discounted as there wasn't a free tier option, as opposed to Firestore which has a money cap that can be sent, making it the more economical choice. Further, it has an automatic scaling option, making it ideal for storing a large amount of outbreak information.

2.2 API Design

2.2.1 General Design

The API will aim to effectively organise and disseminate the outbreak information and reports available on the CDC website. It will be an interface to the database mentioned in section 2.1, the Web Scraper Design. It will allow clients to retrieve information about:

- Diseases
- Any disease outbreaks

The specific endpoints have yet to be decided.

In terms of the API's design, the team considered two approaches towards getting the data:

1. Have the API simply access the data from the database that is filled with data from the periodic web scraper.
2. Everytime the API is called the web scraper and scrapes the requested data accordingly.

Ultimately the team chose the first approach for two reasons. The first is that if the queries are tied to the scraper, in the event that there is a large number of queries, this could result in high traffic on the CDC website themselves and incur high financial costs. The second reason is that we believe that parsing API queries into database queries would be easier in terms of translating that info rather than taking the parameters of the queries and passing them into the scraper.

In terms of the API's authorisation method, we will not be using authorisation such as HTTP Basic, JWT, API Keys or OAUTH. We concluded that the time to implement these features did not confer any noticeable benefits. We posited that if this was a production API where DDoS and high traffic usage were real factors then we would, however given that this is a prototype suce features are not required.

In terms of the design of the API documentation, we will also attempt to have the API conform to the OpenAPI standard. The reason for this decision are the following benefits:

- Following an industry standard will result in a more organised and well-thought-out API.
- OpenAPI can already be easily generated by either SwaggerHub or Stoplight.io.

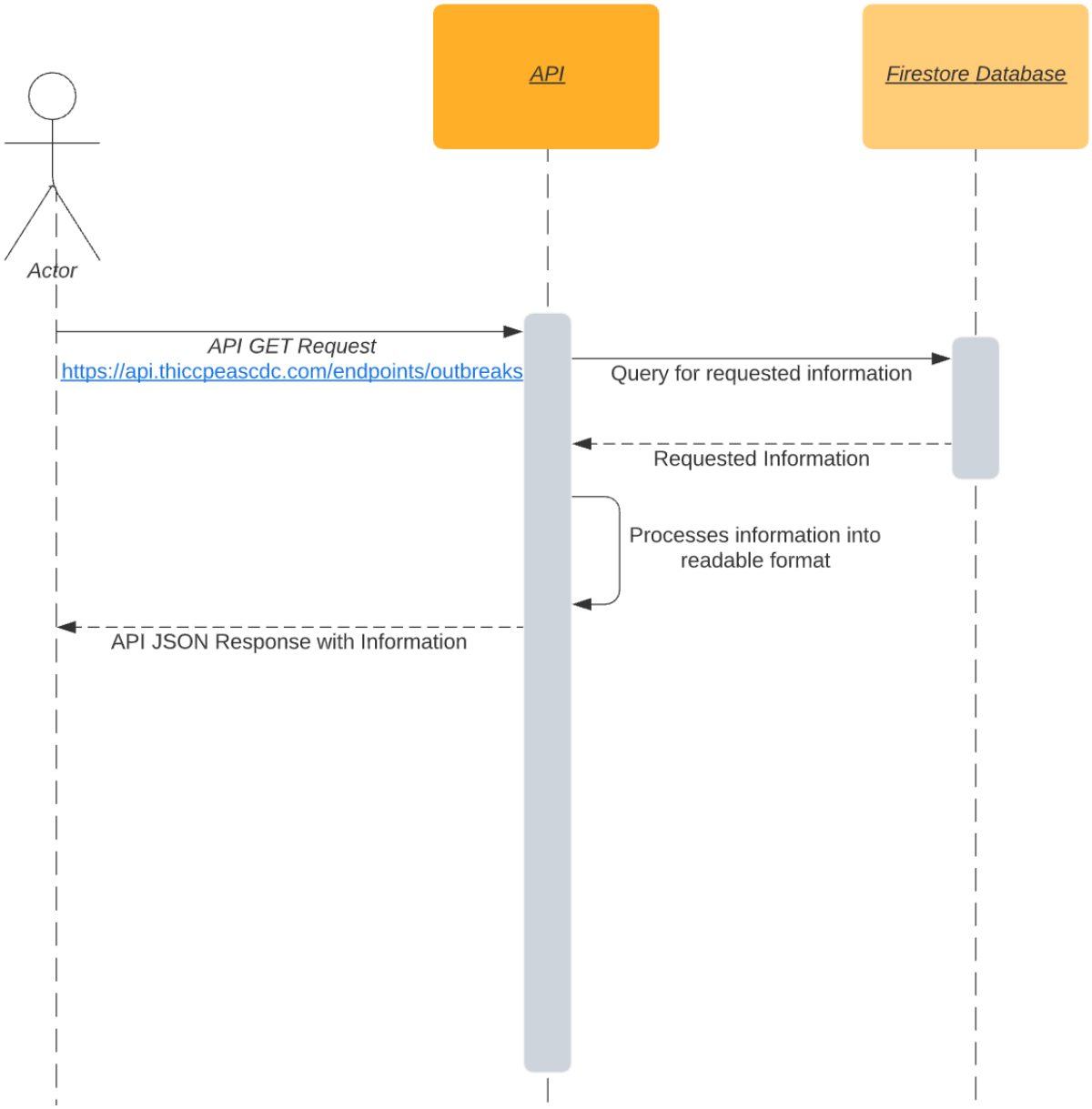


Figure 7: Sequence Diagram of an Example API GET Request

GET Request	Sample Response

GET https://www.api.thiccpeascdc/endpoints/outbre
content-type: application/json
	HTTP/1.1 200 OK
	X-Powered-By: Express
	Content-Type: application/json; charset=utf-8
	Content-Length: 437
	ETag: W/"1b5-el1Vi/mcYseZHVVP9lZR83pmuDQ"
	Date: Fri, 05 Mar 2021 02:46:03 GMT
	Connection: close
	
	{
	"outbreaks": [
	{
	"id": "001",
	"disease_name": "COVID-19",
	"locations": [
	"Lidcome, NSW, Australia"
	],
	"reported_cases": 17,
	"hospitalisations": 2,
	"deaths": 0,
	"start_date": "07-06-20",
	"end_date": "12-06-20",
	"investigation_status": false
	},
	{
	"id": "002",
	"disease_name": "Listeria",
	"locations": [
	"Colorado, United States of America"
	],
	"reported_cases": 2,
	"hospitalisations": 1,
	"deaths": 0,
	"start_date": "07-09-20",
	"end_date": "18-09-20",
	"investigation_status": false
	}
	]
	}

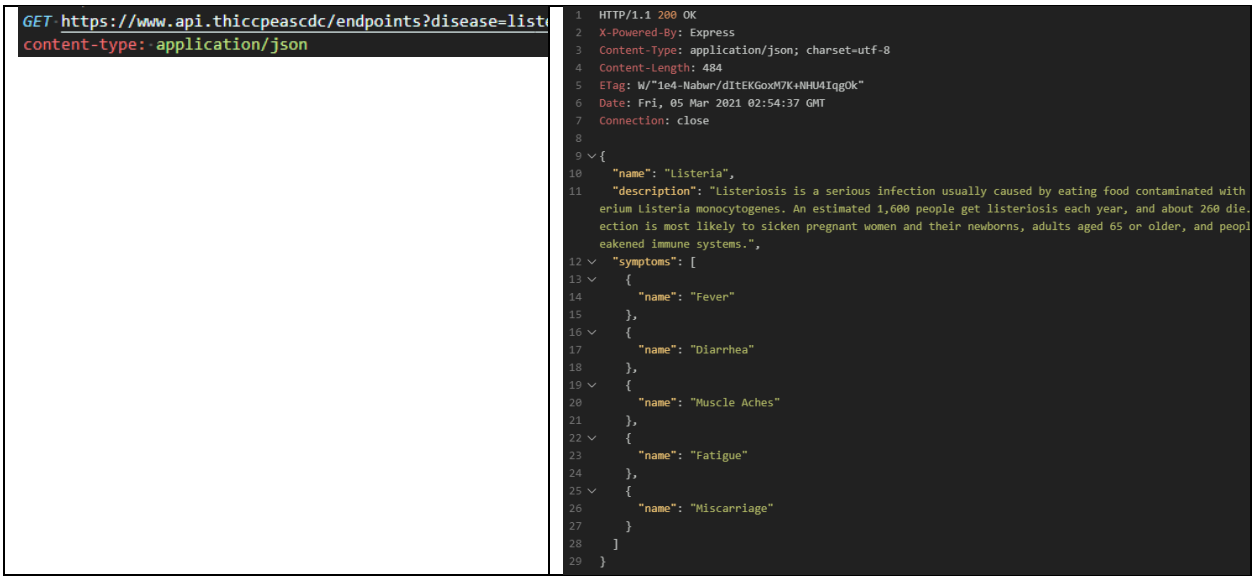


Figure 8: Table of Sample HTTP GET Requests with API

2.2.2 Tech Stack: Language

Language	Team Familiarity	Ease of Use	Amount of Online Documentation
ExpressJS/NodeJS	1/5	Easy	Substantial
ASP.NET Core	2/5	Difficult	Substantial
Flask	3/5	Easy	Substantial
PHP	0/5	Difficult	Substantial

Figure 9: Comparison Table of Possible API Languages

ExpressJS was chosen as the API framework due to its minimalistic nature ensuring ease of development. Combined with its ease of use and our team's familiarity with JavaScript in general, we decided it was the best possible option. Naturally as a result of this, NodeJS will also be used as ExpressJS requires it. Considering NodeJS' popular industry usage and extensive documentation as the back-end environment for APIs, the team deemed it beneficial in the long-term to learn and use it.

In comparison with other technologies, frameworks such as ASP.NET Core and PHP proved to be too difficult to learn and unfamiliar to use. Python's Flask library, a micro web framework that our team had experience with, was considered, however ExpressJS' more popular usage for RESTful APIs and its perceived ease of use compared to Flask caused the team to choose the latter.

2.2.3 Tech Stack: Deployment

To decide what platform we needed to use, the team again decided on GCP, primarily as it was already decided on for the web scraper, and consistency is ideal. We yet again used figure 5 to determine which cloud service to use, as well as our own research.

Ultimately, Cloud Run was chosen over Cloud Function and App Engine. As mentioned in the figure, Cloud Run and App Engine are the more ideal choices for APIs as compared to Cloud Function, mainly because the API requires an always-active URL clients can use to access the API. Cloud Run was chosen over App Engine as although App Engine has less latency than Cloud Run, Cloud Run is only active whenever it receives a request. This means Cloud Run does indeed have a 'cold start', resulting in some lag. This is a minor tradeoff considering the prototypal nature of the project. Thus, Cloud Run is a far more economical choice than a permanently on VPS such as App Engine.

In terms of deployment details, our team will use the official Ubuntu Docker image. This is because the team is very comfortable with Linux, and it is an ideal OS for deploying web services.

2.3 API Documentation Website Design

2.3.1 General Design

API documentation provides reference for developers to the different HTTP endpoints which can be called which would primarily be GET endpoints. The different server response code will be made present for each HTTP endpoint.

Description of each API query will also be made available to the developer, allowing for quick understanding of the query's purpose. The parameters required for specific API query will be made available along with query examples and query response examples to demonstrate the correct method of usage and expected outcome.

An example of a Stoplight documentation GET page is as seen below:

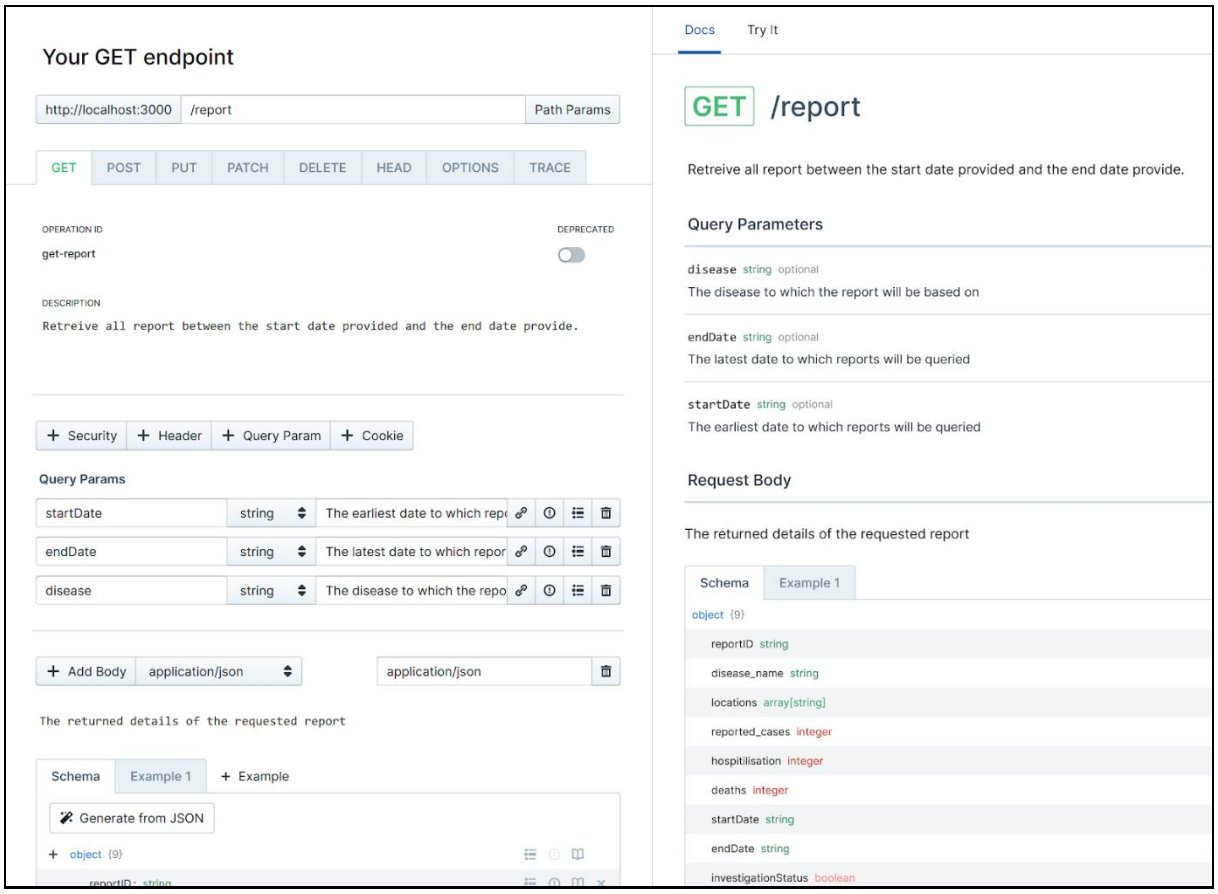


Figure 10: Example Stoplight Documentation

2.3.2 Tech Stack Language

In terms of the API's documentation, there were two tools for API documentation. Swagger and Stoplight. Ultimately, the team chose Stoplight as seen below:

Spotlight's primary advantage over swagger is its ability to collaborate in real time with other team members. This will speed up the writing process as multiple members can use document.

Stoplight.io	**SwaggerHub**
• Spotlight's primary advantage over swagger is its ability to collaborate in real time with other team members. This will speed up the writing process as multiple members can use this. • Spotlight.io has a more easy-to-use GUI than SwaggerHub.	• While collaboration is a possibility, it requires a paid subscription which is not compatible with team budget.

Figure 11: Tech Stack Comparison

2.3.3 Tech Stack Deployment

As the API and Web Scraper is already using Cloud Run, we decided to use a platform from GCP. Using Figure 5 once again, we concluded Cloud Run would be the most economical and best choice.

Since Cloud Function simply executes functions, it is unsuitable for hosting a website. App Engine would work, however its costly 'always-on' nature ruled it out for economic reasons. Thus, the team ultimately decided Cloud Run would be the best option.

The API Documentation website will be hosted on a different Cloud Run instance than the API with a different URL. It will use a Ubuntu image for the docker container. This URL may be of the form: https://www.documentation.thiccpeascdc.com.

In addition, the web server will use Express.JS to serve the web content, as it is what our team is most comfortable with, and we are already using JavaScript and ExpressJS for our API.

2.4 Website Front-End

2.4.1 General Design

The purpose design of the website has yet to be finalised, but is shall abide by the Stage 2 project specification and use APIs to accomplish its goal of contributing the UNSW's epiWATCH.

Web Framework	Familiarity	Ease of Use
React	4/5	Moderate
Vue	1/5	Moderate
ASP.NET	1/5	Difficult

Figure 12: Comparison Table of Possible Web Frameworks

Ultimately, React was chosen as it was the most familiar to our team members, allowing us to create a website efficiently.

2.4.3 Tech Stack Deployment

In order to keep the architecture simplified, our website shall use the same GCP platform as the previous services. Using Figure 5. again, we ultimately decided on Cloud Run, for reasons largely similar to the previous services. Whilst Cloud Functions is simply not sufficient for a website and App Engine being too pricy as an ‘always-on’ service, Cloud Run remains the most economical and efficient choice for the team, especially since the team is already using it.

In addition, the web server will use ExpressJS, as it is what our team is most comfortable with, and we are already using JavaScript and ExpressJS in our architecture.

We plan for the website to be hosted on a separate URL in a separate Cloud Run instance. The Docker container will be the official Ubuntu Linux image as the team is comfortable with Linux and Linux is ideal for hosting a website.

3.0 Architecture Summary

In summary, our API application is mainly hosted on GCP. It will periodically scrape the CDC website for information and deposit that into the Firestore database. Upon client request, the API shall access this database and return the relevant information. For reference, *Figure 13* depicts the broad architecture of the proposed system.

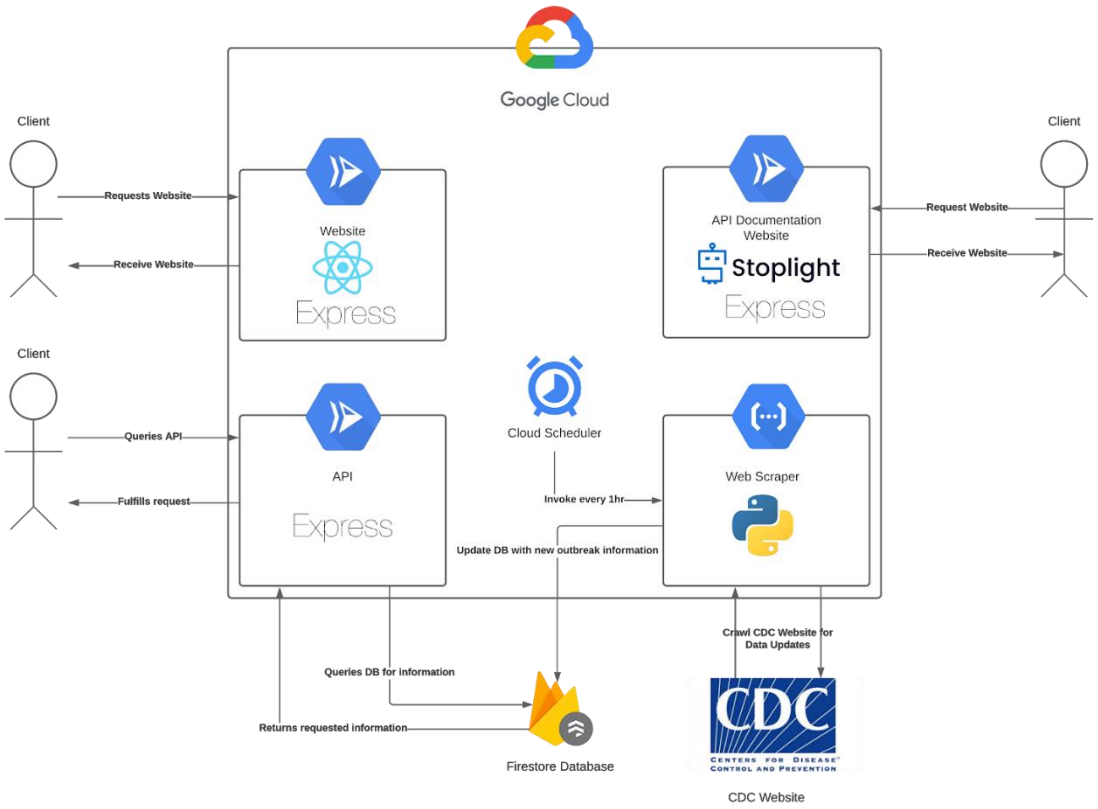


Figure 13: System Architecture Diagram

4.0 Final Architecture

The team since then have implemented an API including all the relevant scrapers necessary. Below are the different challenges that were faced during the development as well the various shortcomings in regard to what was planned and what we ultimately had.

The ER diagram was redesigned:

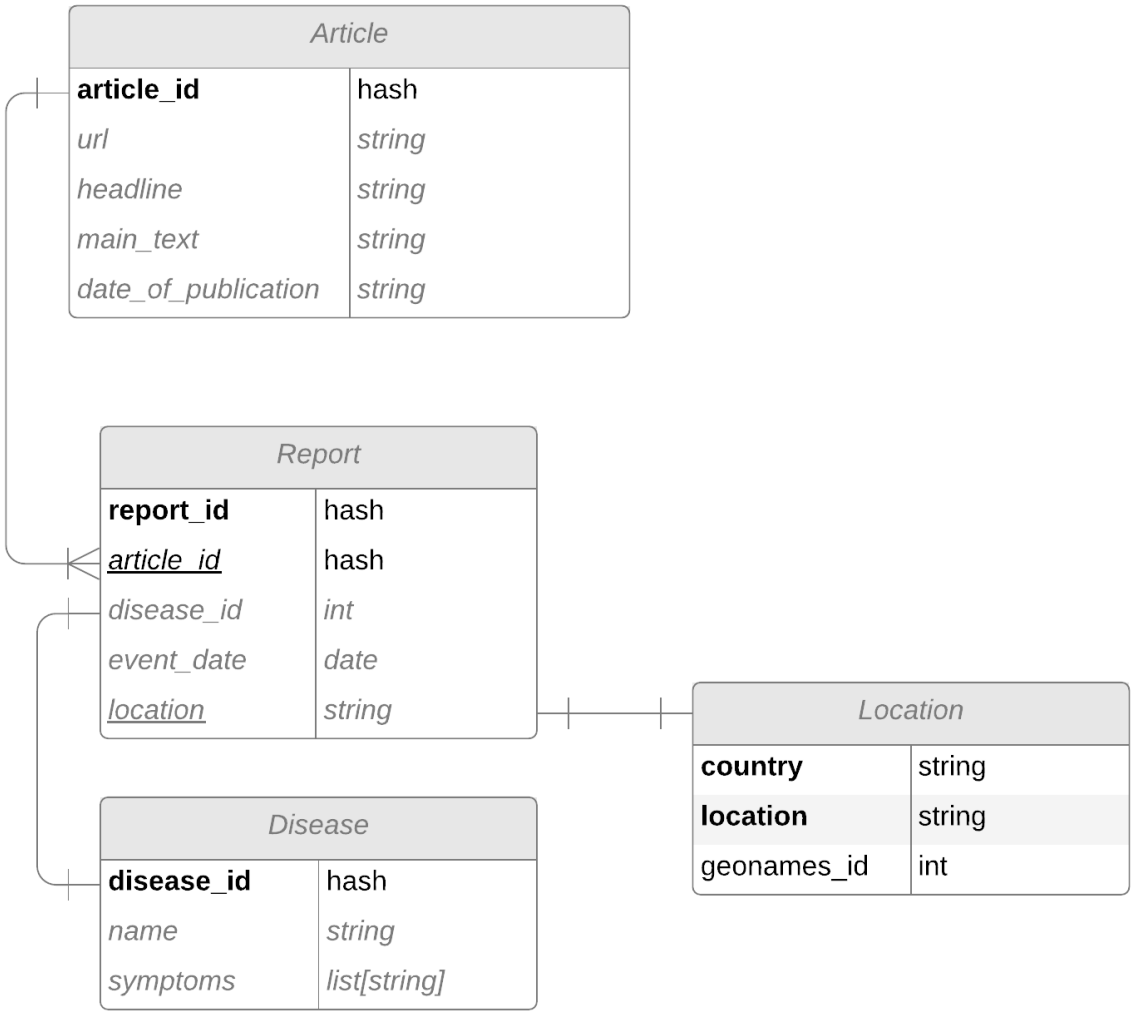


Figure 14. Final Diagram

One issue that the team came across was the updating of the database. Given how the scrapers are written, the scrapers will scrape every report it could every time. This meant that on a consecutive scrape the majority will contain duplicates.

One suggestion was to rebuild the database each time the scrape ran but as time goes on, the database will progressively get bigger and uploading of the data will get progressively longer, making this solution inefficient. Instead, the team decided upon using hashing to help with our duplicates. Every time the scraper is run, the content of each article is concatenated and hashed using the MD5 hash and the resulting hash value acts as the id of the article. During upload the hash of each article is compared with those in the firestore and if they already exist, the article will not be uploaded. The choice of an MD5 hash is its variable to fixed length output and its ease of use.

Below are the challenges and shortcoming faced during the development of the scraper and API

4.1 Scraper

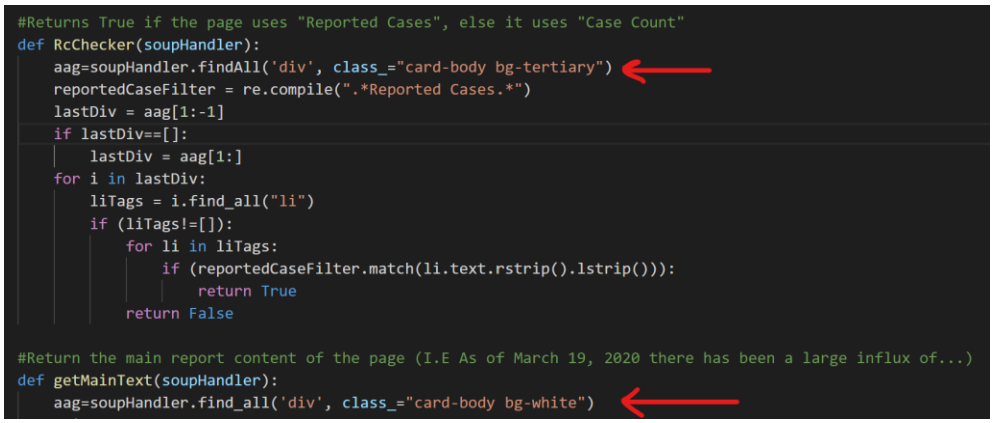
4.1.1 Challenges

Given the data source that we were given, the web scrapers that we have running required a lot of work arounds to get workings. The biggest issue was the inconsistency of the CDC pages regarding outbreaks.

The first inconsistency of the page locations. Since many pages do not share a consistent path to their resource, we had to manually find all possible structure of the URL and then account for their differences. Certain outliers of reports pathways were unscrapable given how inconsistent they were, but we managed to get the large majority of scrapable pages

Secondly, some diseases did not actually have any outbreak reports. So the team chose based on the list given to us in the specification to search for all diseases which did report outbreaks and wrote scrapers for those diseases. Disease such as histoplasmosis does not have any outbreak pages to scrape from, so it is not scraped

Thirdly, since the wording and the HTML structure of the webpages are different, certain specific pages required the scraper to scrape different class types to get the required information. A massive challenge was to make sure we accounted for as many as we can to ensure the database which the API is calling from is as complete as can be. This can be seen in the figure below:



```
#Returns True if the page uses "Reported Cases", else it uses "Case Count"
def RcChecker(soupHandler):
    aag=soupHandler.findAll('div', class_="card-body bg-tertiary")
    reportedCaseFilter = re.compile(".*Reported Cases.*")
    lastDiv = aag[1:-1]
    if lastDiv==[]:
        lastDiv = aag[1:]
    for i in lastDiv:
        liTags = i.find_all("li")
        if (liTags!=[]):
            for li in liTags:
                if (reportedCaseFilter.match(li.text.rstrip().lstrip())):
                    return True
            return False

#Return the main report content of the page (I.E As of March 19, 2020 there has been a large influx of...)
def getMainText(soupHandler):
    aag=soupHandler.find_all('div', class_="card-body bg-white")
```

Figure 15: Difference in pages given their "At A Glance" Box

4.1.2 Shortcomings

The CDC data source, where the scraper had to search had a multitude of issues which resulted in our inability to properly scrape everything to a degree which we were satisfied with. One example of this was for older records of certain diseases, the reference pages containing scanned versions of the reports making them unscrapable. This resulted in only the reports up to a certain year to begin to become scrapable, meaning those reports that came before are not accounted for in the database.

Another issue which we faced was certain diseases themselves did not actually have any outbreak reports as they are either too common to have easily trackable reports or the cases occurring are so few and far between that the reports were aggregated into one data point. Certain outbreak reports were also too vague to scrape the required info, such as titles or main text. There was also no consistent way to scrape all the outbreak reports given that their titles are all worded very differently to find a coherent way to scrape them.

Ultimately, the nature of the CDC website meant that the team was unable to create a master scraper which can scrape all the details needed for our API. Instead, the team opted to create individual scrapers for scrapable diseases available on the CDC which is then hosted in Google Cloud Function which will run on a weekly basis.

4.2 API

4.2.1 Challenges

The firestore database which we used could not run complicated queries like those of SQL based languages. This caused difficulties when attempting to retrieve results from the database to send to the user. Problems include the inability to perform inequality checks for multiple fields, substring checking and regex operation. For example, here we show that when trying to query with ‘start_date’, ‘end_date’ and ‘location’, Firestore will not be able to execute the compound query as it queries multiple fields with inequalities. As seen in figure 16 below:

```
// Get reports according to the correct date ranges.
let reportQueryRef = db.collection(FS_REPORTS_COLLECTION);
if (start_date) reportQueryRef = reportQueryRef.where('event_date', '>=', start_date);
if (end_date) reportQueryRef = reportQueryRef.where('event_date', '<=', end_date);
if (location) reportQueryRef = reportQueryRef.where('location', '>=', location).where('location', '<=', location + '\uf8ff');
```

Figure 16: Inequality operation on multiple fields

To fix this, many of the checks have to be done on the client side to be able to account for those complexities as seen below:

```
// Get reports according to the correct date ranges.
let reportQueryRef = db.collection(FS_REPORTS_COLLECTION);
if (start_date) reportQueryRef = reportQueryRef.where('event_date', '>=', start_date);
if (end_date) reportQueryRef = reportQueryRef.where('event_date', '<=', end_date);

reportQueryRef.get().then(queryResults => {
    let report_result_promises = [];      You, 2 hours ago • Finish /diseases endpoint
    let report_results = [];

    queryResults.forEach(doc => {
        // Create a promise for every report that is going to be added.
        report_result_promises.push(new Promise((resolve, reject) => {
            reportData = doc.data();

            // Create a report_result, which is a combination of a report
            // with its disease and article. This is what we shall
            // send back to the user.
            create_report_result(reportData).then(reportResult => {
                reportData = doc.data(); // Have to recalculate this ofr some reason. If not then the value is cached across all docs.
                articleData = reportResult.article;
                diseaseData = reportResult.disease;

                // Check location query parameter.
                if (location) {
                    if (!reportData.location.toLowerCase().includes(location)) {
                        resolve();
                        return;
                    }
                }
```

Figure 17: Applying the checking operator on multiple fields client side

Here, we had to check the ‘location’ query parameter once we got all the results for the Firestore query. This poses some small performance problems, however there is no real work around this issue with Firestore.